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THE ANNUAL MEETING FOR 1944

The American Association of Economic Entomologists will hold its annual meeting for 1944 in New York on December 13, 14 and 15. Headquarters will be in the Hotel New Yorker.
Morning sessions will be devoted to discussions of general interest including the war Activities of the Association on one day and the Post-War Planning Problems on another day. Afternoon sessions will be for presentation of formal papers and for group and Section meetings.
All members who can do so are urged to attend as the Association is now faced with many problems which need thorough discussion to make possible effective formulation of plans for the future.

E. N. CORY, *Secretary*

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Problems of Medical Entomology of Military Importance in Canada[1]

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Medical entomological problems in relation to the Army in Canada are under the administration and control of the Sub-directorate of Hygiene and Sanitation of the Royal Canadian Army Medical Corps. Research investigations in connection with these problems come under the jurisdiction of the Sub-directorate of Medical Research. This sub-directorate works in close cooperation with the Sub-directorate of Hygiene and Sanitation and is also closely associated with The National Research Council of Canada. Research of an entomological nature is largely carried out by the sub-directorate through the agency of civilian organizations such as the Division of Entomology, Science Service, Department of Agriculture.

Canada at present is fortunate in not being faced with any serious problem in medical entomology. From the standpoint of the Army in Canada, medical entomology is largely a matter of the comfort of the troops, and of making provision against possible insect-transmitted diseases which might become of importance under wartime conditions.

During the past year, amongst problems in Medical Entomology receiving special consideration by the military medical authorities in Canada have been a survey of insect-transmitted diseases in Western Canada, pediculosis, methods of disinfestation, mosquito control, and biting fly repellents.

SURVEY OF INSECT-TRANSMITTED DISEASES.—Bubonic plague, or sylvatic fever as it is known amongst ground squirrels in rural areas, has been reported from Western Canada.

In 1937 a mink fur-farmer in the Hanna area, southern Alberta, died from what was suspected to be plague contracted while collecting ground squirrels and preparing them as food for his mink. This led to the organization of the Alberta plague survey under the direction of Mr. John H. Brown, now of the Department of Entomology, University of Alberta. In 1939 and in 1942 the Alberta survey established the presence of plague-positive ground squirrels in south-eastern Alberta.

Since a number of military establishments are scattered across Western Canada, army authorities deemed it advisable to conduct a survey of insect-transmitted diseases in areas immediately surrounding military establishments, situated between Winnipeg and the Rocky Mountains. Although the survey was primarily concerned with insect-transmitted diseases, some consideration was given to poisonous animals and their possible relation to the troops.

As the areas to be surveyed were scattered across some 800 miles of prairies, 3 survey crews were organized under the field supervision of a suitably-qualified officer (Lt. N. A. Hitchman). Each survey crew consisted of 2 sergeants, one, a veterinarian, and the other a man of suitable biological training. The crew vehicles were 15 cwt. 4×4 Ford personnel trucks equipped as mobile laboratories, each operated by a driver-maintenance man.

In conducting the survey, representative animals were collected from all parts of a block of approximately 4 townships (12×12 miles) having the military establishment in the center. From 12 to 50 or more animals, the number depending on the density of the animal population, were collected from each half-township. Collecting was carried on by shooting and

[1] Presented as a part of the Columbus Symposium, 1943.

trapping. Close watch was kept for dead animals, which, if not too badly decomposed, were included in the collections. Field records were such that it was possible to determine to within a few yards where any animal (or its parasites) was collected. All external parasites were carefully collected and tissue specimens taken from any animal considered suspicious of harboring disease. All animals collected were autopsied and records kept of macroscopic signs of disease. External parasites and tissue specimens were sent to the Department of Pensions and National Health Laboratory at Kamloops, British Columbia, where bacteriological and serological tests were conducted.

(a) During the survey, over 4100 ground squirrels were collected. Of these some 500 showed macroscopic signs of disease. The ground squirrels collected included Richardson's ground squirrel, *Citellus richardsonii;* Franklin's ground squirrel, *Citellus franklinii;* Columbian ground squirrel, *Citellus c. columbianus;* and Striped ground squirrel, *Citellus t. tridecemlineatus.*

(b) Over 700 other animals and birds, of which 130 had macroscopic signs of disease, were collected. These included:

Canada Woodchuck, "Groundhog"	*Marmota monax canadensis* Erxleben
Columbian Ground Squirrel	*Citellus c. columbianus* (Ord)
Franklin's Ground Squirrel, "Grey Gopher," "Bush Gopher"	*Citellus franklinii* (Sabine)
Richardson's Ground Squirrel, "Flicker-tail," "Gopher"	*Citellus richardsonii* (Sabine)
Striped Ground Squirrel	*Citellus t. tridecemlineatus* (Mitchill)
Little Northern Chipmunk	*Eutamias minimus borealis* (Allen)
Mackenzie Red Squirrel	*Tamiasciurus hudsonicus preblei* (Howell)
Osgood White-footed Mouse	*Peromyscus maniculatus osgoodi* Mearns
Athabaska Red-backed Mouse	*Clethrionomys gapperi athabascae* (Preble)
Drummond Meadow Mouse	*Microtus pennsylvanicus drummondii* (Audubon and Bachman)
Lesser Meadow Mouse	*Microtus minor* (Merrian)
Great Plains Muskrat	*Ondatra zibethica cinnamonina* Hollister
Brown Rat, House Rat	*Rattus norvegicus* (Linnaeus)
House Mouse	*Mus m. musculus* Linnaeus
Prairie White-tailed Jack-rabbit	*Lepus townsendii campanius* Hollister
Hudson Bay Snowshoe Rabbit	*Lepus a. americanus* Erxleben
Eastern Porcupine	*Erethizon d. dorsatum* (Linnaeus)
Silver Badger	*Taxidea t. taxus* (Schreber)
Northern Striped Skunk	*Mephitis mephitis hudsonica* Richardson
Long-tailed Weasel	*Mustela frenata longicauda* Bonaparte
Franklin's Gull	*Larus pipixcan* Wagler
Herring Gull	*Larus argentatus smithsonianus* Coues
Black Tern	*Chlidonias nigra surinamensis* (Gmelin)
Marsh Hawk	*Circus hudsonicus* (Linnaeus)
Swainson's Hawk	*Buteo swainsoni* Bonaparte
Eastern Sparrow Hawk	*Falco s. sparverius* Linnaeus
Short-eared Owl	*Asio f. flammeus* (Pontoppidan)
Western Burrowing Owl	*Speotyto cunicularia hypugaea* (Bonaparte)
Shoveller	*Spatula clypeata* (Linnaeus)
Common Mallard	*Anas p. platyrhynchos* Linneaus
Lesser Yellow-legs	*Totanus flavipes* (Gmelin)
Killdeer	*Oxyechus v. vociferus* (Linnaeus)
Ring-necked Pheasant	*Phasianus colchicus torquatus* Gmelin
American Magpie	*Pica pica hudsonia* (Sabine)
Northern Blue Jay	*Cyanocitta c. cristata* (Linnaeus)
Western Crow	*Corvus brachyrhynchos hesperis* Ridgway
Prairie Rattler	*Crotalus v. viridis* Rafinesque

(c) From the animals collected, about 8000 fleas were taken. Unfortunately only a small proportion of these (some 400) were set aside for species determination. The species determined and their hosts were:

Species of Flea	Host Species
Oropsylla rupestris (J.)	Richardson's ground squirrel, Long-tailed weasel.
Neopsylla inopina (R.)	Richardson's ground squirrel
Opisocrostis labis (J. & R.)	Richardson's ground squirrel
Opisocrostis t. tuberculatus (B.)	Richardson's ground squirrel

Opisocrostis bruneri (B.)	Richardson's ground squirrel, Hudson Bay snowshoe rabbit
Rectofrontia fraterna (B.)	Richardson's ground squirrel
Monopsyllus wagneri systaltus (J.)	Richardson's ground squirrel
Cytenophthalmus pseudagrytes (B.)	Richardson's ground squirrel
Thrassis bacchi (R.)	Richardson's ground squirrel
Oropsylla idahoensis (B.)	Columbian ground squirrel
Nosopsyllus fasciatus (Bosc.)	Brown rat

It is interesting to note that 3 species (*Opisocrostis labis*, *Opisocrostis t. tuberculatus*, and *Oropsylla rupestris*) which occurred in 85 out of the 101 collections identified have been demonstrated to be potential plague vectors.

(d) More than 2000 ticks were collected during the survey in southern Alberta and Saskatchewan. These consisted largely of *Dermacentor andersoni*. All ticks were used for bacteriological and serological tests. Species determinations were not made.

RESULTS OF SURVEY.—(1) In some areas, due to macroscopic signs evident on autopsy, a few animals were considered as suspicious of harboring the plague organism (*Pasturella pestis*). These suspicions, however, were not supported by bacteriological and serological laboratory tests.

(2) Previous to the Army survey, tularaemia had been reported by the Alberta survey as present in and to the south of the Lethbridge and Medicine Hat areas, and as suspected of being present in the Calgary area. The Army survey collected tularaemia-positive parasites and animals in several areas of Alberta as far north as Edmonton. Macroscopic signs noted in other animals suggest the disease may be present in other prairie areas.

Positive tularaemia findings were obtained from Rabbit Ticks (*Haemaphysalis palustris*) taken from Hudson Bay Snowshoe Rabbits; tissue specimens from Richardson's Ground Squirrels, Drummond Meadow Mouse, Osgood Whitefooted Mouse, and Franklin's Gull; and a blood sample from a Richardson's Ground Squirrel.

(3) No ticks taken in any military area were positive for Rocky Mountain Spotted Fever.

(4) In cooperation with provincial authorities working on encephalomyelitis, tissue specimens from ground squirrels were sent to provincial laboratories. Brains of Richardson's Ground Squirrels collected in Saskatchewan were shown by the Veterinary Laboratory of the University of Saskatchewan at Saskatoon, to be positive for *Pasturella septicus*, causal organism of haemorrhagic septicaemia of cattle, swine plague, and fowl cholera.

(5) Black widow spiders, *Lactrodectes mactans*, present in parts of Alberta are of little concern to the troops. There are no records of troops having been bitten, even on field maneuvers. Local children in many cases handle these spiders as freely as they do spiders of other species.

PEDICULOSIS.—Exclusive of the pediculosis problem introduced by the arrival in Canada of large numbers of Prisoners of War, pediculosis has not been of any great importance amongst the troops.

Body lice infestations have been practically nil. The very occasional infestation that has occurred has been promptly controlled by disinfestation and cleanliness.

Public lice also have been of slight importance. From time to time a few cases of infestation occur, usually the result of activities whilst on leave. These are usually dealt with by the unit medical officer, and controlled by the applicatilon of standard remedies and disinfestation of clothing and bedding.

Head lice did, for a time, give promise of becoming a major problem amongst members of the Canadian Women's Army Corps. Medical officers at a training center reported a varying percentage of infested personnel amongst the incoming drafts from different depots. Infestations varied in degree from cases where comparatively few nits were present to cases where individual hairs might have 3 or 4 nits attached. Live lice were seldom seen on examination.

From detailed records kept on infested personnel, it was evident that these infestations were a carryover from crowded civil living and employment conditions. The majority of infested personnel, before enlistment, had been employed in various war industries where employees usually worked in shifts and where caps were sometimes used by successive shifts or kept in common containers when not in use.

As a result of careful head inspections

carried on by competent personnel, and the prompt application of control measures on enlistment, and on being posted to training centers or duty elsewhere, the incidence of pediculosis humanis capitis has been reduced to a very low level. Practically no infestations have been contracted at military establishments after enlistment.

Since personal appearance is an important consideration to members of the Canadian Women's Army Corps, it is not practical to control head lice by the application of a lotion that must remain on the head long enough to kill the nits when they hatch. Treatment at present is based on the use of a lotion, thoroughly rubbed into the hair, and left on overnight before the hair is rinsed. A lotion with a high flash point is preferable. Tests of various lotions were carried out on infested personnel. At the present time, a lotion containing thanite appears promising. This lotion does not produce serious dermatitis and is not distasteful to the personnel treated. In the tests conducted, following one application left on overnight, no live nits were recovered.

The same lotion is being tested on male and female (volunteers) soldiers as a control for pubic lice. Present indications are that it will give effective control although productive of slightly more irritation when applied to the pubic regions. This irritation however is no greater than with some so-called standard remedies and is seldom followed by desquamation of the areas treated.

DISINFESTATION.—Until comparatively recently (exclusive of disinfestation in connection with prisoners of war) the need of disinfestation in Canada has been in connection with occasional pediculosis infestations. This need has been met by the dry heat disinfestors installed at district depots and camps in each military district or by commercial operators.

With the organization of the Returned Stores Section of the Royal Canadian Ordnance Corps, where serviceable used stores are reconditioned, and unserviceable stores are salvaged, the problem of disinfestation changed materially. The large volume of stores to be disinfested as a precautionary measure to protect personnel handling them and to prevent the spread of such vermin as lice, bedbugs, and clothes moths, into new stores, necessitated the construction of additional disinfestors of greater capacity.

In view of the labor involved in disinfesting the large volume of stores handled by the Returned Stores Depots, different methods of commercial disinfestation were investigated. Based on the data collected, a fumigant was selected, a directive was issued, and this method of disinfestation was put into operation.

Later, as a check to determine the efficiency of disinfestation of returned stores the medical research sub-directorate, in cooperation with the Division of Entomology, Science Service, Department of Agriculture, ran tests with live insects in one of the Returned Stores fumigation vaults. This test indicated that the kill being obtained was negligible. This low kill was largely attributed to lack of appreciation of the problems involved in fumigation by personnel responsible for the operation of the vault.

After the suggested modifications in structure and operation of the vault had been carried out further tests were conducted. By this time cold weather had set in and the operator of the vault had been changed. In these tests, a kill of 30% was obtained. This low kill was considered to be due to incomplete penetration resulting from the manner in which, to economize on labor, the stores were placed in the vault.

As a result of the difficulty in securing experienced operators, training, and retaining operators when trained, the necessity of removing stores from cases and cartons prior to fumigation, and the hazards attendant upon inadequate aeration during cold weather, the use of a fumigant for disinfestation purposes is being discontinued in favor of the dry heat method.

Some research has been carried out to adapt bags, paper, anti-gas, for use in delousing an individual soldier's clothing and bedding. Bags, paper, anti-gas, are an issue for use in handling gas-contaminated clothing. By minor modifications made to existing bags, they may be satisfactorily used with an ampule of disinfectant, for delousing purposes.

MOSQUITOES.—Conditions in early spring of 1943 were favorable for the development of a heavy mosquito population in some training areas of Western Canada. To prevent undue interference

with training, mosquito control was initiated in a few areas. Waste crank-case oil cut with kerosene or diesel oil was applied by hand sprayers to temporary ponds and sloughs in these areas. When applied in the absence of wind (early morning or early evening) good control was obtained, the larval population of one 700-acre slough being reduced from 360 per cu. ft. at the commencement of oiling to 3 per cubic feet when oiling was discontinued. When oil was applied through the day, regardless of the prevailing winds, poor control resulted.

Repellents.—Research on repellents was carried out in the past season. Tests of various repellents and combinations received from the Division of Entomology, Science Service, Department of Agriculture, from the Orlando Laboratory of the United States Bureau of Entomology and Plant Quarantine, and from England, and prepared according to formulae of the research divisions, D.G.M.S. Directorate, by the Central Medical Stores, were conducted in Saskatchewan, Ontario, and Quebec.

Several repellents and combinations gave protection time of 4 hours or more under service conditions, when test personnel were perspiring but slightly or not at all. Under conditions of moderate perspiration, the repellent time was reduced by approximately 33 per cent, under conditions of profuse perspiration, the repellent time was reduced to approximately 20 per cent.

The species of mosquitoes present during the test were *Aëdes campestris*, *A. spenceri*, *A. cataphylla*, *A. dorsalis*, and *A. intrudens*.

Although during these tests, mosquitoes were present in swarms about the test personnel, the biting rate averaged from 1 to 5 bites per minute.—12-7-43.

Relation of Insects to the Health of Military Personnel[1]

O. R. McCoy, *Major, Medical Corps, A.U.S., Tropical Disease Control Section, Division of Preventive Medicine, Office of the Surgeon General*

Introduction.—The fact that insects are concerned in the transmission of disease to human beings was first demonstrated in 1878 by Sir Patrick Manson in China, who showed that *Culex* mosquitoes are involved in the transmission of filariasis. Since that date a series of epoch-making discoveries have demonstrated many of the most important diseases of man to be carried by insects. The list of insect-borne diseases has grown to an imposing length and additions to it are still being made. For instance, in the past few years culicine mosquitoes have been incriminated as probable vectors of certain encephalitides in man and animals in our western states.

Since many of the insects which act as disease vectors flourish in warm climates, insect-borne diseases, particularly malaria, are of great military importance in the tropics and subtropics where much of the present war is being fought. Our armies in New Guinea, the Solomon Islands, Sicily, Southern Italy, and Assam are campaigning in some of the most malarious areas of the world. Many other troops are stationed in or travel through the Caribbean, eastern South America and West Africa. Hence it is not surprising that malaria and other insect-borne diseases are a constant menace to be reckoned with.

The military importance of insect-borne disease has been amply demonstrated by past experience. Battles and even entire military campaigns often have been influenced by the occurrence of such diseases as plague, typhus, yellow fever, and malaria in the opposing armies. For example, the Haitian Republic owes its independence to yellow fever. Napoleon sent an army of 20,000 men to put down a rebellion among the natives but it was so severely decimated by yellow fever that it could not conduct an effective campaign. During World War I both typhus and malaria had an important influence on campaigns in the Balkans. Severe outbreaks of typhus fever in Serbia prevented an invasion by the Austrians during the first winter of the war. Later, malaria

[1] Presented as a part of the Columbus Symposium, 1943.

seriously interfered with the conduct of military operations by both German and Allied armies in the Macedonian area. About 80 per cent of a French army of 125,000 troops were hospitalized and the admission rate among the British army was almost as great. In the year 1918, 25,000 British soldiers were sent home from Macedonia because of chronic malaria. Fortunately, the German army suffered from the disease to an exqual extent so that the armies on both sides were immobilized.

MEDICAL IMPORTANCE OF INSECTS.—Insects, or more properly speaking, insects and arachnids, may be of medical importance in various ways. Sometimes they act as parasites and invade the tissues. This is true of certain fly larvae which enter wounds, or penetrate the skin or normal body openings and cause myiasis, and also the itch mite which burrows in the skin and produces the condition known as scabies. Other arachnids, such as scorpions and certain spiders, cause painful and occasionally serious injury from toxic reactions following their bites or stings. Biting flies, chiggers, and other pests sometimes may be very irritating and annoying, as has been true in certain maneuver areas in our southern states. In general, however, the military medical importance of the insects of this type is not very great, except possibly the mite causing scabies. Although seldom incapacitating, scabies may sometimes be exceedingly troublesome and has been known to cause more man-days to be lost in an army than other diseases better known and more spectacular in their effects. Fortunately, scabies thus far has not been a source of much trouble in our own army.

By far the greatest medical importance of insects lies in their ability to transmit disease organisms from man to man or from animals to man. Sometimes the insect acts as a biological vector, that is, the disease organism multiplies or undergoes an essential part of its life cycle in the insect host as, for example, malaria parasites in *Anopheles* mosquitoes, typhus organisms in lice, plague bacilli in fleas, and so on. Other insects may act as mechanical disseminators of disease organisms which adhere to the exterior of their bodies and on their legs and mouth parts. The housefly is a notorious example of this means of disease dissemination. Since this paper is being presented before an entomological audience, the diseases to be discussed will be arranged according to their insect vector rather than according to the type of causal agent. The military importance of the principal insect-borne diseases will be reviewed, particularly in relation to the present conflict.

MOSQUITO-BORNE DISEASES.—Malaria is by far the most important of the mosquito-borne diseases. In fact, from a world-wide point of view, it is probably the most important of all diseases. Its military importance cannot be overemphasized. In certain active theaters malaria has caused many more casualties than enemy action. However, in all sectors, even where tropical *falciparum* malaria predominates, the number of deaths from malaria has been extremely small. The malaria problem in the Army is mainly one of man-days lost, and men kept from active duty by relapses.

The Army has mobilized its resources to combat the menace of malaria. Malariologists, parasitologists, entomologists and sanitary engineers have been specially trained and incorporated into a control organization which functions in all overseas theaters. Through such agencies as the National Research Council and the United States Department of Agriculture, The Surgeon General has promoted investigations to improve our weapons for fighting malaria. Repellents far more effective than any hitherto known have been developed. New methods of using insecticides have been worked out and it is fair to say that we are much better prepared now to deal with malaria than we were at the start of the war.

The problem of military malaria control differs from that in the civilian community because often there is neither time nor opportunity to apply the mosquito control measures which are standard in civilian practice. Troops in combat must employ individual measures of protection against mosquitoes until the area is occupied and standard measures for mosquito control, such as draining and larviciding of breeding places, can be instituted. The individual measures applied in forward areas include the use of repellents, sleeping nets, and spraying to kill infected adult mosquitoes. The effectiveness of individual protective measures de-

pends upon the amount of malaria training that units have received and the degree of malaria discipline that is enforced. Emphasis is now directed to the improvement of malaria discipline so that noneffectiveness from this disease in forward areas will be reduced. Entomologists through their research investigations and their active participation in malaria control in the field are playing an important role in fighting this enemy in and behind our battle lines.

In earlier times yellow fever would have been a serious menace in those sections of tropical America and Africa where our troops have been stationed during the present war. For more than twenty years yellow fever has been practically eradicated from the larger cities of this hemisphere where formerly it had raged unchecked. However, the disease has persisted in jungle areas and remains a constant threat. The development of a highly effective vaccine against yellow fever by members of the Rockefeller Foundation in the last decade provided a means of individual protection in addition to the group protection that is provided by control of the *Aëdes aegypti* vector. All troops stationed in or traveling through potential yellow fever zones are inoculated with vaccine. Hence there is little likelihood of yellow fever causing any appreciable loss in the armed forces.

The great danger from yellow fever is that infected mosquitoes or individuals may be transported into regions which heretofore have been free from the disease. In the Orient particularly, conditions are favorable for spread, and calamitous civilian epidemics might occur if the disease was once introduced. The military importance of such an occurrence in an area serving as a base for our armies is obvious. Strict precautions are prescribed that airplanes traveling through yellow fever territory be sprayed to destroy insects which might be transported. Individuals must be vaccinated against yellow fever before being allowed to enter yellow fever territory. With the great increase in airplane travel, both commercial and military, this problem has become increasingly important. The Army is cooperating with the United States Public Health Service in this country and with local governments abroad to prevent any introduction of infected mosquitoes or individuals in areas free from yellow fever.

Precautions against the transport of insects by airplane are necessary not only to prevent spread of yellow fever but also to prevent the introduction of various other disease vectors into new territory. The experiences resulting from the introduction of *Anopheles gambiae* into northeastern Brazil ten years ago are still fresh in everyone's memory. The presence of this highly efficient vector of malaria brought about extensive epidemics in areas where previously the disease had been only mildly endemic. The present heavy travel over the southern Atlantic air route offers possibility of the reintroduction of the dangerous *Anopheles gambiae* into Brazil, or spread eastward into the Middle East and India. Constant vigilance is required to guard against such an occurrence.

Although the South-Sea islands are free from malaria they are plagued by another mosquito-borne disease known as filariasis. This disease, caused by a worm parasite which invades the lymphatics, is transmitted by various culicine mosquitoes, and has widespread distribution in the tropics. During the present war it has been of military importance in the South Pacific where the rate of infection among the natives on many islands is very high. A high density of infected individuals and mosquito vectors is required for transmission of the disease. Early in the war large numbers of men were suddenly moved into these endemic regions and of necessity were housed in close association with the native population. As conditions become stabilized and mosquito control measures are applied, filariasis becomes less of a military problem. In any event, there is small likelihood that our men will acquire sufficient infection to suffer the severe effects of filariasis that are frequent in heavily infected natives.

There is one other mosquito-borne disease, known as dengue fever, which frequently is of considerable military importance. Dengue, like yellow fever, is caused by a virus and is transmitted by *Aëdes aegypti* and other species of *Aëdes*. It is widely distributed in the tropics and occasional epidemics have occurred in our southern states. Although very uncomfortable to the patient, the disease is limited to a course of from five to seven days and is practically never fatal. Since it typically occurs in explosive epidemics,

dengue is of military importance because of the high rate of noneffectiveness which it may cause. One attack usually confers immunity. In the South and Southwest Pacific dengue has appeared from time to time in epidemic form. An outbreak of dengue occurred recently in Hawaii. Fortunately, spread to the military forces there has so far been prevented. Control measures directed against *Aëdes* mosquitoes, which are indicated to prevent spread of yellow fever and filariasis, are also necessary to control the spread of dengue.

LOUSE-BORNE DISEASES.—Typhus, trench fever, and relapsing fever are diseases that may be transmitted by lice. Of these, typhus is by far the most important from a military standpoint. Because conditions of crowding and lack of facilities for washing and laundry favor the propagation of lice, typhus for centuries has been a scourge of armies in the field. The ravages of typhus in the Balkans during the last war have already been mentioned. Strenuous application of delousing measures by the Germans prevented the introduction of typhus among armies on the Western front, in spite of the fact that the disease was endemic in the Balkans and also in Poland on the Eastern front. After the war tremendous epidemics, which took an enormous toll of life, occurred in eastern Europe and Russia.

The Army now has much better protection against typhus than was possible in the last war. In recent years a vaccine has been developed which is effective in producing at least partial immunity to the disease. All troops serving in potential typhus areas are inoculated with this vaccine. In addition, louse powders and delousing methods have been greatly improved so that lousiness among soldiers is much more easily controlled.

Typhus is endemic in North Africa, Spain, the Balkans, eastern Europe and various parts of the near East and the Orient. We have already heard reports of epidemics among the civilian population in many of these places. With the disturbed conditions which prevail in wartime further epidemics may be expected. In view of the protective measures, both with vaccine and against lice, which are given to our troops, it is not expected that serious epidemics can develop in our Army. However, any widespread epidemics which might occur among civilian populations in territory occupied by the Army would have important influence on military operations. The United States of America Typhus Commission, with members from the Army, the Navy, and the Public Health Service, has been established by the President to deal with the problems of typhus fever arising during the course of the war and afterwards.

Trench fever is a rickettsial disease related to typhus fever but not nearly so severe in its effects. It was common during the last war but apparently died out soon afterward. Although there have been reports of its possible re-appearance in Poland since the start of the present war, there has been no indication that it has become epidemic. Antilouse measures to prevent typhus will also serve to prevent trench fever. This is equally true for relapsing fever, a spirochetal disease, the epidemic form of which is transmitted by lice.

MITE-BORNE DISEASE.—Another rickettsial disease popularly known as "scrub typhus," is transmitted by larval mites belonging to the genus *Trombicula*. It occurs in various parts of the Orient from Japan southward to Malaya and the Dutch East Indies. In Japan it has been known for many years as tsutsugamushi disease and has shown a case-mortality rate of about 40 per cent. It is only recently that the disease has been recognized in the Dutch East Indies. There the case-fatality rate is usually much lower, less than 10 per cent. The vaccine which gives protection against typhus fever confers no immunity against "scrub typhus." The new repellents which are useful against mosquitoes also serve to repel mites. The use of repellents, the wearing of protective clothing, and the clearing of vegetation around encampments are the chief means of protecting troops who must operate in jungle areas where this mite-borne disease is prevalent.

FLEA-BORNE DISEASES.—Flea-borne diseases include bubonic plague and endemic typhus fever. Both are primarily diseases of rodents, particularly rats, and are transmitted from rat to rat by fleas. Transmission to human beings occurs by the bite of infected rat fleas. As the name suggests, endemic typhus occurs only sporadically, both in the southern part of this country and abroad. The disease is

similar to epidemic typhus except that usually it is more mild. Only occasional cases have occurred in the Army in the continental United States.

Although plague was a frequent devastator of armies in medieval times, the disease has not been epidemic among modern armies. However, epidemics still occur in civilian populations, especially in India and other parts of the Orient. Vaccines against plague have been developed but their use in the Army is limited to personnel located in districts where they are particularly exposed to the disease. Epidemics of plague are likely only when there is close contact between human beings and large numbers of rats. The sanitation enforced in modern armies has greatly reduced the hazard from this diesase which once practically wiped out entire armies.

Diseases Transmitted by Flies.—Diarrhea and dysentery have always held high rank as a cause of noneffectiveness among military personnel. The present war is no exception. Flies, such as the common housefly and related varieties, are an important factor in the spread of the organisms which cause enteric disease. The old saying, "feces, flies, food" is vividly explanatory of the relationship. The filthy feeding habits of flies and their proneness to regurgitate while feeding contribute to their ability to transmit disease organisms. Furthermore, it is well-known that amoebic cysts may survive passage through a fly's intestine.

Dissemination of dysentery organisms by flies depends primarily on insanitary disposal of feces. Proper sanitation of a military encampment fails to accomplish its whole purpose if natives pollute the near-by premises. It goes without saying that very primitive sanitary conditions prevail in most of the areas where our armies are now operating. Measures to combat flies, therefore, have an important place in the Army's program of sanitation. Screening of mess halls and use of insecticides are essential items. Proper disposal of human wastes is a paramount consideration not only to lessen chance of food contamination by flies but also to prevent feces from serving as a breeding place for flies.

Biting flies, which feed upon blood, may act as biological vectors of a number of human diseases. The tsetse fly is the vector of African sleeping sickness, a disease caused by protozoan blood parasites known as trypanosomes. This disease is limited to the tropical parts of Africa because the tsetse fly vector is not found in other parts of the world. Although this disease is very deadly in areas where it is endemic, it is not likely to be of great military importance for the reason that few of our troops operate in these regions. The possibility of the spread of tsetse flies by aircraft cannot be forgotten. Spraying measures applied primarily against yellow fever and malarial mosquitoes also serve to prevent the introduction of tsetse flies to areas where they do not now exist.

Sandflies, which belong to the genus *Phlebotomus*, serve as vectors of several diseases. From a military viewpoint sandfly fever, also known as pappataci fever, is the most important. This disease is caused by a filtrable virus, and is, in many ways, similar to dengue fever. The course is short, and like dengue, the mortality rate is practically nil. However, when sandfly fever occurs as an epidemic it may cause serious noneffectiveness in an army. The small size of the transmitting insect and its peculiar breeding habits necessitate control measures distinct from those which are useful against mosquitoes. For example, in sandfly areas nets of finer mesh than those ordinarily used to keep out mosquitoes must be employed. The larvae of sandflies develop in damp earth and special procedures are required to destroy them.

Leishmaniasis, both the dermal and the visceral forms, are transmitted by sandflies. Protozoan tissue parasites are the causative agent. Leishmaniasis is endemic in Central and South America, in the Mediterranean region, parts of Africa, the Near East and the Orient. Although occasional cases may appear among our troops, the likelihood of extensive epidemics is not considered great.

Onchocerciasis, a disease caused by a filarial worm which lives in subcutaneous tissue nodules, is transmitted by black flies belonging to the genus *Simulium*. This disease has limited distribution in Central America and tropical Africa. It is not likely to be of any military importance. This is true of several other filarial parasites which also are transmitted by biting flies.

Diseases Transmitted by Ticks.—

Rocky Mountain fever, a rickettsial disease transmitted by ticks, belonging to the genus *Dermacentor*, is well-known in this country. Similar rickettsial and other diseases which are tick-borne occur in various parts of the world but their distribution is limited. Occasional cases of Rocky Mountain spotted fever occur in the Army, especially among troops on maneuvers. The risk of infection, however, has not been great enough to warrant the inoculation of military personnel with the protective vaccine which is available. A few cases of tick-borne tularemia have been reported.

Relapsing fever is another disease which may be transmitted by ticks. Members of the family Argasidae are responsible. Although practically worldwide in distribution, cases of relapsing fever following tick bites are usually sporadic. Tick-borne diseases do not constitute an appreciable military problem.

SUMMARY.—The importance of insects to the health of military personnel depends not only upon the variety of diseases which they transmit but principally upon the extreme importance of a certain few. From experience in the present war to date it is obvious that the *Anopheles* mosquito is a major enemy. Combat against this seemingly insignificant insect attains an importance rivaling the war against our human enemies. After malaria, dengue, sandfly fever and filariasis are the insect-borne diseases which cause the greatest losses in effectiveness. This list does not include diarrhea and dysentery because insects are only one of many factors in their spread. The role of flies in their dissemination, particularly among military personnel, is, however, important in considering the influence of insects on the health of troops.

Protective inoculations have greatly lessened the danger of typhus and yellow fever to military personnel. None the less, these diseases retain great importance because of the constant threat of epidemics in civilian populations and the resulting influence on military operations in affected areas. Other insect transmitted diseases, although frequently of great local importance, do not constitute appreciable military problems because of the small likelihood of many cases occurring among military personnel. They cannot be neglected, however, and some, such as plague, are always a potential source of danger to man.

The war against insects requires the same elements as a military campaign. Trained personnel must be provided to plan and carry out control measures. Maintenance of insecticide supplies and equipment is essential in regions where insect-borne diseases are prevalent. Advances in knowledge concerning our insect enemies make possible improved methods of control. New chemicals effective against insects have value comparable to the "secret weapons" of real warfare. Contributions of the entomologists of this country in the waging of the war against insects occupy a prominent place in the total war effort.—12-7-43.

JOHN S. HOUSER RECEIVES DEGREE

At its annual commencement in May, 1944, Kansas State College bestowed the degree of Doctor of Science on three distinguished alumni who had graduated from that institution just forty years previous to the event.

Dr. Houser's accomplishments in the field of entomology formed the background for the award. These are so outstanding and so well known to all entomologists that they need no elaboration at this time. Since Dr. Houser has already been the recipient of the highest honor which our Association can bestow, nothing remains but to extend our congratulations and to claim for all entomologists a share of the satisfaction which must come from this award.

OTTO H. SWEZEY HONORED

At its annual commencement on June 9, the University of Hawaii conferred the honorary degree of Doctor of Science upon Otto H. Swezey. Mr. Swezey was in distinguished company as the same degree was conferred at this time on Admiral Chester W. Nimitz. Dr. Swezey has been an entomologist in Hawaii for forty years during which time he has rendered notable service to the Islands. He was one of the founders of the Hawaii Entomological Society, twice served as its president and edited its proceedings for thirty-seven years. We will take the liberty of extending the felicitations of the membership of the *Association* to Dr. Swezey on the occasion of this well-deserved recognition.

Entomologists and the Sanitary Corps[1]

W. A. HARDENBERGH, *Colonel, Sanitary Corps, U. S. Army*

1. One of the problems, that occupied the attention of the Medical Department of the Army early in the mobilization program, was that of the control of malaria. At that time, the principal problem of immediate interest was malaria control within the limits of the continental United States. A large number of camps were being located within the southern states where anopheline mosquitoes are present, and the population is sufficiently infected to provide the mechanism for the spread of malaria. Later this program had to be extended to include the many foreign bases, into which United States troops were sent, and such areas as Panama and Puerto Rico, where military requirements necessitated stationing personnel in unprotected regions as at search light and listening posts and anti-aircraft installations. In addition, there is now the serious problem of malaria control in the combat areas, including specially the Southwest Pacific, the South Pacific, the Middle East, and the Mediterranean.

2. In some sections sandflies present a problem; and such pests as flies, roaches, and bedbugs normally are prevalent wherever large groups of men are gathered together. In planning for the control of these insects, whether pestiferous or disease-bearing, it was necessary to call upon the entomological profession for advice and assistance.

3. Entomologists had little previous opportunity to utilize their peculiar skills and training in the Army. Apparently little planning had been done in this regard and the Sanitary Corps Reserve had less than 15 entomologists among its personnel. Even this small number, however, seemed adequate in late 1940, when the program of mosquito control in this country was first given consideration. It was planned to station these men in service command laboratories in the Southeast and Southwest and in all of the principal camps in the more malarious areas. Accordingly, early in 1941 these Reserve officers were ordered to duty, being reinforced by two others who had been commissioned meantime. The value of the work they performed soon became so clearly evident that, when authority was granted early in 1942 to enlarge the Sanitary Corps, additional entomologists were immediately commissioned. The need for them has grown until at present there probably are more entomologists in the Sanitary Corps of the Army than in any other single activity in the country. At this time entomologists are stationed in all of the principal camps throughout the malarious sections of the country; the number on duty in these camps represents several times the number originally in the Sanitary Corps Reserve.

4. These officers are engaged in mosquito and pest control in relation to general sanitation. The mosquito control activities include surveys to determine the prevalence, type, and habits of mosquitoes which may transmit malaria, and recommendations in regard to control measures. In addition, the problem of bedbug and roach control has become a highly important one. It is a job in which entomologists are being relied upon more and more for advice and supervision. Though both of these problems—mosquito control and pest control—are responsibilities of the Corps of Engineers so far as the performance of the work is concerned, the Medical Department is charged with the responsibility for technical supervision and advice. Disinfestation of barracks by the Army is being accomplished in a most satisfactory manner and at a cost much lower than would be possible if the work were carried out by commercial disinfestors. In addition to these principal duties of insect control, entomologists occasionally have been used, when their services were available from insect control, in general sanitation. Such duties include the routine sanitary and mess inspections that are required to keep our camps in satisfactory condition.

5. The services of entomologists have been required at ports of embarkation and debarkation for delousing and disinfestation, to serve the troops housed in these areas, for prisoners of war, and personnel returning from overseas theaters. Entomologists have been used in a number of

[1] Presented at the conference of entomologists of the Entomological Society of America and American Association of Economic Entomologists, Columbus, Ohio, 7–9 December 1943.

schools as instructors, it being our opinion, that the sanitary engineers and Medical officers at these schools should be taught the ways in which entomologists can be of service to them in preserving the health of the Army. This procedure is in line with the recognized policy that effective control can be accomplished only through team work among all specialists in public health.

6. It has been found desirable in some service commands and other overhead installations to assign entomologists to perform administrative functions where their training and experience could be utilized in a broader field. This is especially true in the service commands and service command laboratories throughout the South, where malaria is a special problem, where pestiferous insects are more numerous and likely to cause greater difficulty than in the North, and where more troops are housed.

7. Perhaps the greatest use of entomologists has been in malaria survey units. A large number of these units have been organized and sent into the field and are now serving in every part of the world where malaria is a problem. The duties of these units comprise general and specific surveys of mosquito adults and larvae to determine their incidence, distribution, and relation to malaria; preparation of recommendations as to control measures for specific areas; collection of adults and larvae to check effectiveness of control measures; malaria parasite surveys to check effectiveness of therapeutic and suppressive treatment and control; maintenance of records and spot maps to make available for the surgeon a clear and continuous picture of the malaria situation. The unit is in effect a mobile malaria laboratory; it determines what must be done to reduce the mosquito population to a level consistent with the requirements for health protection. More and more units are being requested for overseas areas and it is the consensus of opinion of those familiar with their work, that they have been invaluable in the Army's campaign to protect the troops against malaria infection.

8. In addition to these assignments, entomologists are on duty with the Army Air Forces, in the Surgeon General's office, in the Civil Affairs Division, Allied Military Government, of the Provost Marshal General's office; and on foreign duty other than with survey units.

9. Inasmuch as entomologists are commissioned and utilized through the Sanitary Corps, the history and general composition of that Corps may be of interest. The Sanitary Corps is designed to provide for the Medical Department the nonmedical technical health personnel required to round out the Army's program of preventive medicine. The Sanitary Corps includes, in addition to entomologists, sanitary engineers, bacteriologists, serologists, parasitologists, food and nutrition officers, and a few other smaller categories. In general, the requirements for admission are the same for all of this technical personnel. The basic minimum requirements are four years of college with a suitable degree and two years of satisfactory experience. Entomologists are now serving in the Sanitary Corps up to and including the grade of lieutenant colonel. There are, roughly, 2 lieutenant colonels, 5 majors, and 25 captains per hundred, which is about the average of rank throughout the Sanitary Corps.

10. Medical entomologists have proved to be so much better equipped for the work the Army requires to be done that so far as possible all appointments have been made from men with training and experience in this field of work. On the other hand, a number of agricultural and economic entomologists are now serving with the Sanitary Corps and have performed very satisfactory service. Most of the men commissioned in the original reserve were experienced mainly in these fields.

11. A few additional entomologists will be required during the next few months. None will be appointed from civil life as it is believed that the number of qualified enlisted men now in the Army will be sufficient for all needs, even though appointments are restricted to those who have had experience in medical entomology. Enlisted men are commissioned direct from the ranks on their educational and experience qualifications, if they have attained their thirtieth birthday. There is no officer candidate school or other training school for enlisted men and therefore this is the only means by which an enlisted man may be commissioned. It is believed that by the end of the war the number of entomologists in the Army will

be between 20 and 25 times as great as that available in the Sanitary Corps at the beginning of the war.

12. All newly commissioned officers are given a 6-week indoctrination course at the Medical Field Service School, Carlisle Barracks, Pennsylvania. This course is not designed to teach them entomology but to equip them to be officers of the Army of the United States. The Fourth Service Command Laboratory at Fort McPherson, Georgia, has a training course which instructs the officers of this service command in the duties of an entomologist at a post, camp, or station. In collaboration with the Florida State Department of Health, a three-week course in field malaria control is given to entomologists and sanitary engineers who are doing malaria control work in this country or who are being activated for overseas duty in malaria control. Under the Army Mobilization Training Program, all personnel of Malaria Survey Units are given at least a one-month training course in malaria control.

13. The services of our Sanitary Corps entomologists have been highly satisfactory and their work has been a potent factor in the reduction of malaria as well as in the control of other insects not considered to be vectors of disease. The services they have rendered have been an education to all of us. We have been especially impressed by the soundness of entomological training and the ability of entomologists generally to adapt themselves to the conditions existing in the Army. We would like to take this opportunity to express our appreciation for the interest of the many men in charge of entomological work in the various colleges who have cooperated with us in selecting personnel. We would like especially to state our appreciation of the work of Dr. F. C. Bishopp of the Department of Agriculture, upon whom we have leaned very heavily in the selection of personnel and in the adoption of policies regarding entomological work. We hope that in the postwar Sanitary Corps, whether active or inactive, entomologists will be a strong force, both in number and in quality.—12-7-43.

The Malaria Control Program of the U. S. Public Health Service[1]

STANLEY B. FREEBORN, *Sr. Surgeon* (R) *U. S. Public Health Service*

The present malaria control program of the U. S. Public Health Service is an emergency measure designed to protect vital war workers. It is complementary to the anti-anopheline programs carried on by the Army and Navy in that we protect an area of approximately a mile in radius outside the boundaries of the establishments to correspond with the areas that the armed forces are controlling within the reservation.

In addition, the program includes control methods surrounding vital war industries and recreational and housing areas designed for service men or war workers.

The actual control operations are directed by the individual State Departments of Health with funds, equipment, and policy making as well as technical advice supplied by the Service.

The unit of operation is the "area," the size of which is limited by the ability of one man, the area supervisor, to direct conveniently. These areas are divided into zones which surround the individual establishments that are being protected. They are close enough together to be supervised by the area supervisor but far enough apart so that they do not overlap.

Our operations generally include a one mile zone about the protected establishment but this is flexible depending on the flight range of the vector concerned.

For purposes of administration of the Division of States Relations of the U. S. Public Health Service the country is divided into Public Health Service districts with offices located at strategic spots with-

[1] Joint Meeting—American Association Economic Entomologists and Entomological Society of America, Columbus, Ohio, December 7, 1943.

in each district. Each of these districts which is concerned in the Malaria Control in War Areas program has a district MCWA engineer and entomologist assigned to it. The function of these men is to aid the State personnel in their districts as representatives of the district and the headquarters office of the program.

An operational division in the headquarters office made up of sections devoted to entomology, engineering, medicine and the *Aëdes aegypti* program correlates the work of these sections, facilitates their activities and maintains the proper liaison with other functions of the Service and the armed forces.

We are now cooperating with twenty States, Puerto Rico, Hawaii, and the District of Columbia in the protection of approximately 1200 war establishments. In addition we are operating, in cooperation with the states and cities concerned, *anti-aegypti* campaigns in twelve cities in five states and one territory as a part of the mandate entrusted to the Service.

The program is primarily designed for the emergency. Hence larviciding has played a more prominent role than in normal anti-mosquito programs. We have practiced species sanitation against *Anopheles quadrimaculatus*, *A. freeborni* and *A. albimanus* and largely ignored the other anophelines and pest mosquitoes except as they were eliminated as part of our regular program. Oiling and dusting with paris green have been standard procedures but trials late in the season with some of the new organic insecticides and oil emulsions were so promising that next year's program may find a place for these innovations.

Drainage and filling have been utilized whenever their use affected larviciding to the extent that (1) it had to be done to make treatment possible and (2) where its cost would be amortized in five years in terms of larviciding costs.

Permanent drainage structures such as ditch lining, tile, sand traps and tide gates have been used occasionally where conditions of soil or terrain made other expedients infeasible. Most cases of this sort were limited to the vicinity of permanent establishments and were subsidized by local sub-divisions of government.

We have not hesitated to use heavy equipment whenever it was indicated that it would conserve manpower. In fact the cost yardstick of the whole program has been the "man-day" rather than the "dollar." Despite this viewpoint, however, we feel that our costs have been exceptionally low. In the last fiscal year the entire cost of the program including all overhead expenses, equipment, supplies and technical personnel averaged one dollar per man-hour for all personnel at the field level. When it is recalled that in some areas the prevailing wage for the lowest paid laborers on our program was 85 cents per hour, it would seem that the program is an economical one despite the fact that this is not our primary goal.

The biological yardstick of the program is, of course, the prevention of malaria among the protected personnel. In the face of a declining malaria rate it is difficult to make any claims for the program. However, I am sure that we can point with modesty in company with the medical authorities of the Army to the fact that despite the introduction of literally millions of non-immune service men into areas of endemic malaria, that the malaria incidence rate for locally acquired infections is the lowest in the history of the Army. At this point it should be noted that both the Army and Navy have been keenly aware of the problem and have conducted control programs within their respective reservations that closely approximated perfection.

Malaria in the continental United States is something of an anomaly. In this area it is a disease characteristic of pioneer conditions and yet it is perpetuated by man made factors. It has become dangerous both in the past and at present in those areas which have perpetuated the pioneering characteristics of housing and living and in addition have accentuated the breeding of our anopheline vectors by disturbing the natural course of drainage in the countryside by impoundage, irrigation, or construction work.

In some respects it is a very fortunate coincidence that our principal carriers, *Anopheles quadrimaculatus* in the East and *A. freeborni* in the West, are so closely attuned to life in accumulations of water that are generally traceable to attempted manipulations by man. Except for the correction of impoundments there is generally little opposition and frequently generous cooperation in attempts to correct faulty water management. It is equally

fortunate that the biting habits of these two vectors are such that slight improvements in housing conditions frequently tip the balance against transmission.

The interaction of these two factors has been largely responsible for the recession of malaria from its highwater mark in the 1880's when it was the scourge of practically all of humid United States, to its present limited areas of the southeast. It is equally the hope upon which a plan for the eradication of malaria from continental United States has recently been proposed.

For many years Dr. Louis L. Williams, Jr., of the Public Health Service, has held a high place in the councils of those who were thinking and doing things about malaria. He has a characteristic way of absorbing present day facts and after fitting them into the fund of information acquired by long experience of producing a solution for the problem that immediately becomes perfectly obvious. However, when his answer as to what steps should be undertaken to handle the problem of malaria carriers among the returning service men was a suggestion that we attempt to eradicate malaria from continental United States most of us felt that finally he had pushed his luck or his enthusiasm too far.

However, he marshalled his facts and presented the story. The number of his disciples grew to the point where at a meeting of the National Malaria Society last month, at which were assembled some of the keenest as well as the most experienced malaria fighters in the nation, his program to eradicate malaria from this country was approved unanimously.

Time will not permit an adequate explanation of this program which envisages the eradication of malaria by a reduction of anopheline vectors coupled with steps to protect potential victims from anopheline bites. It is not necessary to point out to this group that malaria eradication does not necessarily involve anopheline or even *quadrimaculatus* eradication but simply a reduction in numbers that will make the odds for easy transmission too long to be of economic importance. The more favorable the ecological conditions of an area are for transmission the greater this reduction must be. The proposed attack is directed against the spots of easy transmission—the endemic foci. Its success will depend, not only on the adequacy of the control work, but on the basic assumption that in most other areas of the country human carriers are now so few in number that malaria is not perpetuating itself.

The problem of returning malaria carriers among Army and Navy personnel may complicate the "best laid plans." However, we feel that a concerted attack such as Dr. Williams proposes is the best method of handling this potential menace.

It has been pointed out by some who are perhaps more closely attuned to politics and economics than they are to biology and the public health that this program would constitute an excellent post war project when manpower shortages were less stringent. If conditions remain static with little or no upswing of malaria rates as the result of returning malaria carriers or biological trends little ground will have been lost by the delay.

However, as entomologists we know that any fight in which insects are concerned is a rough and tumble one with no holds barred and no quarter given or expected. Without any apologies therefore to the Marquis of Queensberry I would advocate very earnestly that malaria, while it is still "down," be neatly and expeditiously eliminated from the face of continental United States.—12-7-43.

LAUREN D. ANDERSON

Dr. Lauren D. Anderson, of the Virginia Truck Experiment Station at Norfolk, is on leave of absence from his Station and is working on problems of mosquito control for the Bureau of Entomology and Plant Quarantine. Dr. Anderson may be addressed at his permanent address in Norfolk as his actual present address is subject to censorship restrictions.

Insect Control at Army Training Camps[1]

STANLEY J. CARPENTER,[2] *Fourth Service Command, Ft. McPherson, Georgia*

With the establishment of Army training camps in connection with our mobilization program it soon became apparent that many of the problems confronting the Medical Department of our Army were of an entomological nature. Early in this program it was realized that trained entomologists would be necessary to do entomological work in many of the larger camps, particularly those located in the Southern United States.

Most of the entomologists holding reserve commissions were called to active duty during the early part of 1941. As our training program was expanded and our troops began moving out into other regions of the world, in many of which malaria and other important insect-borne diseases are common, the need for entomologists increased until we now have several hundred commissioned entomologists in the Army serving in training camps and with our troops in the field.

We have had various types of insect problems deserving the attention of an entomologist at practically every military camp in this country, but due to the importance of malaria in parts of the United States as well as in the combat zones, many of the commissioned entomologists are engaged in mosquito control work particularly in the Southeastern United States where malaria is endemic.

According to Army regulations it is the responsibility of the commanding officer of a military installation to take such steps as may be necessary to protect the health of his personnel due to the presence of insects. The surgeon is responsible, under the commanding officer, for investigating the prevalence, distribution, and significant habits of insects. He is also responsible for recommending control measures, providing technical supervision, and checking on and reporting upon the adequacy of control measures effected. The post engineer, under the direction of the commanding officer is charged with the technical supervision and execution of insect control work on real property other than ordinary housekeeping by troop units or individuals.

In order to obtain information on insect problems in the Army camps and the duties of entomologists assigned to training camps in this country a questionnaire was prepared by the writer and sent to the Chief of the Medical Branch in each of the nine service commands. Much of this paper is based on information obtained by this means.

TRAINING OF ENTOMOLOGISTS.—Some of our entomologists have not had previous civilian experience in the identification and control of insects of medical importance; therefore it was necessary to give these men training along these lines shortly after assignment to duty. Due to the many insect problems encountered in the South, this training was especially valuable in the Fourth Service Command. In this command, entomologists receive training in the identification and control of insects of medical importance in the Entomology Section of the Fourth Service Command Medical Laboratory as well as practical training in the application of control measures at the larger camps. The First Service Command and others, on a smaller scale, have conducted classes for enlisted men in the identification and control of insects of medical importance.

The Entomology Section of the Fourth Service Command Laboratory offers the following courses for training entomologists and Medical Department technicians: An orientation course for newly assigned officers, a course in mosquito identification and control for entomologists, and a course in malaria prevention for enlisted technicians. These courses are briefly described.

The Fourth Service Command has recently adopted the policy of sending officer entomologists who have had no previous experience in the identification and control of mosquitoes to this laboratory for a period of orientation. This enables them to become acquainted with the insect survey and control methods being practiced throughout the Service Command before reporting to their respective camps for duty. During 1943, 22 entomologists, newly assigned to this Service Command,

[1] Prepared for the symposium on "Medical Entomology in Wartime" held at the joint meeting of the American Association of Economic Entomologists and the Entomological Society of America.

[2] Major, Sanitary Corps, A.U.S.

have received this training. Following this course of instruction at the laboratory the less experienced men are frequently assigned to larger camps where they are allowed to work with experienced entomologists for a few months. Entomologists who have had civilian experience in the field of medical entomology are usually assigned directly to a camp upon reporting to this Service Command.

A course in mosquito identification and control is given by this laboratory for officer entomologists and enlisted men who have had college training in entomology. The course deals mainly with the identification, and control of the different species of mosquitoes occurring in the Southeastern United States and some of the more important anopheline species of other parts of the world. A few other groups of arthropods of medical importance are studied, including flies, fleas, and ticks. Five classes have been scheduled for the winter of 1943–44. This course has proven valuable to entomologists who have been assigned to malaria survey teams for overseas duty.

During the spring of 1943 a course of instruction in malaria prevention was organized at the laboratory for training enlisted technicians from the different military installations in the Service Command where malaria control work was needed. The men received classroom instruction in the recognition of the common anopheline mosquitoes of the southeastern states, the separation of mosquitoes from other insects taken in light trap collections, mosquito control, the preparation of equipment used in collecting mosquitoes, and methods of packing, recording, and shipping specimens to be identified. The men were given actual field experience in setting up mosquito collecting stations and the techniques of collecting mosquitoes both in the larval and adult stages.

Although this course was designed primarily for the training of men who could be used to assist entomologists and sanitary engineers in mosquito collection and control, some instruction was also given in the application of control measures used against other insects known to be of importance in Army camps. These men are now rendering valuable service in the supervision of insect control throughout the Service Command. The value of this course cannot be overemphasized since it has resulted in an amazing improvement in the entire mosquito control program.

During 1943, organized courses for training of insect control workers have been held in four of the nine service commands. In most cases these schools were sponsored jointly by the Medical Department and the Corps of Engineers. The instruction is usually provided by entomologists and sanitary engineers and consists of lectures, demonstrations and field trips pertaining to the control of mosquitoes, bedbugs, roaches, flies, fleas, and any other insects presenting a problem of medical importance in the area. Schools have been held in several Service Commands for the training of fumigation crews to carry on bedbug control in the different camps. A great deal of individual instruction in insect control has been given in the different camps by entomologists stationed at the Service Command Headquarters who visit the camps regularly for this purpose. The Bureau of Entomology and Plant Quarantine has rendered valuable assistance by furnishing a liaison entomologist who visits the entomologists of the Sanitary Corps giving whatever aid is necessary.

MOSQUITO CONTROL.—Malaria constitutes a serious hazard to military operations in many parts of the world. If we consider the regions in which our troops are fighting and the difficulties encountered in attempting to do malaria prevention during combat we should easily understand the problem.

In this country mosquito control as practiced by the Army is confined to the limits of the military reservations; and where necessary to protect the health of the troops, extra-cantonment control is the responsibility of the United States Public Health Service.

During 1943 the Army carried on mosquito control at approximately 303 posts. The distribution of these control projects by service commands was approximately as follows: First 13, Second 29, Third 16, Fourth 100, Fifth 27, Sixth 17, Seventh 25, Eighth 59, Ninth 17.

MOSQUITO COLLECTION PROGRAM.—In order to keep a check on the abundance and distribution of *Anopheles quadrimaculatus* as well as certain other mosquitoes of importance a system of weekly collections and reporting has been instituted at

most of the Army posts in the Fourth Service Command. These collections are of four types and are as follows: diurnal resting station, light trap, biting and larval. A description of the mosquito collecting program in the Fourth Service Command is given as an example of work being done by entomologists in malarious regions of this country.

The collections are made by entomologists and their assistants at the larger posts and by enlisted technicians of the Medical Department at the smaller posts. The mosquito collections are prepared for shipment at the close of each week and sent to the Fourth Service Command Laboratory for identification or confirmation of identifications made by local personnel.

After a rather complete initial mosquito survey has been made on each post for the purpose of determining the nature of the mosquito problem, a series of collecting stations are established from which collections are obtained.

A series of 10 to 25 permanent resting stations are established in each camp from which adult mosquitoes are collected. Diurnal resting stations selected for weekly mosquito collections usually consist of dark, cool shelters including small areas inside buildings, underneath barracks, culverts, and hollow trees. In the absence of natural occurring shelters the use of well-placed boxes, nail kegs or specially constructed small buildings will adequately fill this need.

From one to six New Jersey type mosquito light traps, depending on the size of the cantonment area, are placed at favorable locations for sampling the mosquitoes that actually invade the camp. The traps are operated three nights during each week and at the end of each period the mosquito specimens are separated from the other insects by the local personnel. The number of *Anopheles quadrimaculatus* taken in traps is usually lower than the number taken in well-selected diurnal shelters. However, light trap catches seem to indicate trends in abundance in a comparable manner.

Records of the number of mosquitoes attempting to feed give direct information on the kinds that are causing annoyance and their relative abundance. Most of the biting records are made at dusk or after dark and are obtained either by two persons, one collecting from the other, or by one person collecting alone. Collections of this type are made weekly at several points in the camp area and are of particular value as a supplemental measure for giving a more complete picture of the details of the mosquito problem.

A series of larval collections are likewise made weekly to provide exact information on: (1) the areas producing species of economic importance, (2) the need for larval control, (3) the effectiveness of the larvicidal program, and (4) changes in breeding conditions that may occur. A larval station may consist of a pond, lake, section of a stream, or a series of temporary pools in a particular area offering a similar aquatic environment.

The exact locations of all mosquito collecting stations on each post are indicated by number and type on an appropriate map, copies of which are furnished the Chief of the Medical Branch of the Fourth Service Command and the Fourth Service Command Laboratory, so that the exact location of each collection, in relation to living quarters, can be determined. In addition to the weekly collections obtained from established collecting stations, most camps find it necessary to make some miscellaneous collections each week in order to obtain a true picture of the mosquito problem.

At the close of each week the collections for this period are packed and shipped to Service Command Laboratory where specific identifications are made. Identifications are usually made within two or three days and at the end of that time a completed copy of the identification report and the specimens are returned to the particular camp. A summary of the weekly collections by types is maintained on a large wall chart at the laboratory and summaries of these identifications are furnished the Chief of the Medical Branch of the Service Command so that current comparisons of mosquito catches in the different camps can be made with little difficulty.

The Fourth Service Command Laboratory identified weekly mosquito collections from 142 Army installations comprising a total of approximately 540,000 adult and 152,000 larval mosquito specimens from January through October 1943.

As an incidental result of these mosquito collections, over 70 new state rec-

ords, one new record for the continental United States and one new species of *Aëdes* have been added to our knowledge.

HOUSEFLIES.—Due to the Army emphasis on general sanitation, conditions in permanent camps are seldom conducive to heavy production of houseflies. Serious fly problems are more frequently noted in quarters constructed near the reservation boundary and adjacent to large civilian populations. Fly problems of a serious nature have also been encountered in a few instances in maneuver areas where basic principles of sanitation were not adhered to in a strict manner.

Reports indicate that flies constitute an important problem which requires constant attention over the entire country. The following are some of the control procedures reported by the different Service Commands: The elimination of off-post nuisances through cooperation of local health authorities; elimination of breeding places within the posts principally by proper construction and care of garbage racks and incinerators; the proper care of stables, compost piles, and sludge beds at sewage plants; the proper construction and maintenance of straddle trenches and privies in bivouac and maneuver areas; and the usual control measures applied against adult flies including screens, fly paper, swatting, traps, and insect sprays.

Under laboratory conditions flies are able to transmit certain organisms which can cause human diseases. Flies have been found under natural conditions infected with pathogenic organisms and have frequently been accused of transmitting certain gastro-intestinal diseases. The assumption that such transmission occurs is generally accepted and is probably true but actually proving that specific outbreaks of certain diseases were fly borne has been very difficult.

STABLEFLIES.—The stablefly or "Dog Fly" breeds extensively in certain marine grass deposits along the shores of bays and estuaries of Northwestern Florida and has presented a distinct problem at certain military installations. The United States Public Health Service and the Bureau of Entomology and Plant Quarantine have conducted, during recent years, a joint "Dog Fly" control project for the protection of military personnel stationed in this region.

BEDBUGS.—Information obtained by means of the questionnaire sent to all Service Commands indicates that bedbugs have presented an important problem in training camps throughout most of the country. It has been pointed out in most of these reports that, by training personnel to recognize light infestations during periodical inspections, the bedbugs can usually be controlled with liquid sprays. All nine Service Commands are fumigating to eliminate heavy infestations of bedbugs which have developed beyond control by less effective measures. Some degree of success has been obtained in certain areas during the summer months by superheating of buildings but this method has apparently not been very practical due to the nature of the construction of most barracks and the difficulties encountered in burning out furnace grates when superheating has been attempted.

ROACHES.—Reports which have been received indicate that roaches present an important problem in all nine Service Commands. Heavy infestations are limited in most camps to mess halls, post exchanges, and hospitals. Practically all of these reports stress the importance of mess hall sanitation and frequent inspections to prevent heavy roach infestations. It has been noted that well-kept mess halls seldom have heavy roach infestations which would require any treatment other than liquid spray or the application of a satisfactory roach powder.

Five of the Service Commands indicated that fumigation is being used to clear up heavy roach infestations. Four Service Commands reported that sodium fluoride was being generally used for the control of roaches in Army camps, two others indicated that roach powder was being used but did not indicate the particular kind in use, while two Service Commands reported the use of liquid sprays against light infestations and fumigation for the elimination of heavy infestations.

FLEAS.—Reports indicate that there has been very little work done toward the control of fleas in Army camps in the United States other than in some of those located in the Fourth, Eighth and Ninth Service Commands. Flea control in the Fourth Service Command, where endemic typhus presents a potential problem, is directed chiefly against rats. Rat control has consisted largely of rat-proof-

ing buildings, trapping, poisoning and fumigation. In the Ninth Service Command where sylvatic plague is known to be a potential danger in certain areas, flea control is being accomplished through rodent control measures, including carbon disulphide directed against ground squirrels and trapping and fumigation for rats.

Cases of endemic typhus occurring among military personnel in the Fourth Service Command have been somewhat concentrated in the Gulf Coast area and in Southern Georgia. At one Army post a few cases of endemic typhus occurred almost simultaneously among military personnel all of whom gave a history of having visited a night club where the proprietor and his wife had both recently had the disease. Two additional cases developed later giving similar histories. The night club was closed and fumigated and no additional cases occurred in that particular area.

TICKS.—Answers received to the questionnaire sent to the Chief of the Medical Branch of each Service Command indicate that tick problems have been encountered by the Army in certain regions in the United States, particularly in maneuver areas in the Fourth, Seventh, Eighth, and Ninth Service Commands.

Several cases of tularemia have occurred among military personnel in the Tennessee Maneuver Area and in Southern Mississippi in the Fourth Service Command, practically all of whom gave recent histories of having been bitten by ticks. Although the "Lone Star Tick" (*Amblyomma americanum*) has not been definitely incriminated in the transmission of this disease in nature, epidemiological evidence points to this species as being the possible vector in each of these areas. The "Lone Star Tick" is also suspected of being the transmitting agent for Bullis fever, a disease which has recently appeared in Texas. There have been only a few scattered cases of Rocky Mountain spotted fever among military personnel in the United States during our present training program.

LICE.—Reports indicate that occasional human infestations by lice have been encountered in most of the Service Commands. Infestations appear to be more common among war prisoners at the time of their arrival at ports of entry. The common control practices reported where these infestations have occurred include disinfestation of clothing by means of steam sterilization and fumigation with methyl bromide.

It has been necessary on numerous occasions for the Medical Department to recommend and in many cases supervise control measures against other insects of lesser importance which have presented problems at the various Army camps in this country.

In conclusion, entomologists are contributing a great deal to the war effort especially by their contributions toward intelligent and effective control of insect-borne diseases. Experience gained by entomologists of the Sanitary Corps in Army camps in the United States is a necessary prerequisite for the more important job of controlling insects of medical importance throughout the various theaters of operation.—12-7-43.

DR. STEARNS RETURNS TO DELAWARE

Lt. Col. Louis A. Stearns, Sn.C., AUS, reverted to inactive status as of the 9th of September, 1944 and has resumed his former position as Head of the Department of Entomology, University of Delaware, Newark. During 2 years and 3 months of military service, Colonel Stearns completed the course in Tropical Medicine at the Army Medical School, Washington, D. C.; acted as Staff Sanitary Officer with the 9th Air Force in India, Egypt and Libya, was Staff Malariologist for the Persian Gulf Command in Iraq and Iran; and served lastly as Director, Division of Entomology, Army School of Malariology in Panama. He was awarded the Asiatic-Pacific, the European-African-Middle Eastern and the American Campaign Ribbons for service in all three theaters of operations.

Entomological Services on the Program for Malaria Control in War Areas[1]

G. H. Bradley, *Senior Entomologist* (R) *U. S. Public Health Service*

The principal method of malaria control practiced on the Malaria Control in War Areas program of the Public Health Service is that of attacking the mosquito vector of that disease by eliminating its breeding places or preventing adult emergence by periodic application of larvicides. Although all of this work falls within the field of economic entomology, on our program a division of work is made. The entomological section, as such, is concerned with gathering and interpreting entomological data for use in planning and guiding the mosquito control work, while the engineering section is charged with the planning and execution of the actual control operations. By making initial entomological surveys and by maintaining a constant surveillance of the control projects the entomological service provides information to make possible the following operational practices:

(1) Limit control work in any area to the specific mosquito concerned with malaria transmission.
(2) Restrict control work to those localities where the densities of the malaria vector are high enough to constitute a malaria hazard.
(3) Determine the effectiveness of routine control operations so that supplemental measures or revised control procedures may be instituted when indicated.

The desirability of these practices will probably not be questioned by this audience. However, we are frequently called on to justify the need for this regulatory work.

Concerning the first of these exigencies, viz., that of limiting control work to the specific mosquito responsible for transmitting malaria, it has long been known that in any malarious area there is usually but one species of anopheline responsible for perpetuating the disease. Credit for discovering and first expounding this important contribution to malariology is due to Dr. S. T. Darling, who, while working in Panama about 30 years ago, found that *Anopheles albimanus* was the chief malaria transmitter of that region and who demonstrated that measures directed against that one species were successful in controlling malaria. However, this practice, which is termed "*Anopheles* species control of malaria" or "species sanitation," was not adopted in any large measure in the United States until quite recently. Rather, anti-mosquito work in malaria control in this country was directed against all anophelines and too frequently against all mosquitoes. It is realized that such all-inclusive mosquito control work is highly desirable in many areas as a civic improvement measure and will, of course, control malaria if it is successful in sufficiently reducing the density of the vector. However, malaria control in this country undoubtedly has been greatly retarded by such procedures because of the much greater expense involved, the longer period of time necessary in obtaining results, the frequent failure and loss of interest in these projects and the antagonism of many persons and organizations to the necessary wide-scale drainage operations. For these reasons malaria mosquito control work on the MCWA program is being directed solely against the vector species—*Anopheles quadrimaculatus* in the East and Southeast, *A. freeborni* in the Far West and *A. albimanus* in the lower Rio Grande Valley and in Puerto Rico. The epidemiological evidence incriminating these species as the anophelines responsible for perpetuating malaria in these regions is such that there is little likelihood of others being concerned. Even when present in excessive abundance under conditions apparently favoring transmission, others of our common anophelines, such as *A. punctipennis*, *A. crucians* and *A. occidentalis* have not been incriminated in malaria epidemics.

Anopheline mosquitoes vary greatly in their breeding, flight, biting and associational habits, not only between species, but within the individual species in different latitudes and at different seasons. Biting, associational and longevity habits, together with the customs of the human population within its range are all-impor-

[1] Presented as a part of the Columbus Symposium, 1943.

tant in determining the probability that an individual anopheline species will transmit malaria, while breeding and flight habits are all-important in determining the nature and extent of necessary control measures. A study of these habits of the vector in each locality is therefore necessary in order to devise control procedures best suited to the job.

The restriction of control work to those localities where the vector densities are sufficiently high to constitute a malaria hazard involves decisions which frequently are difficult to make. We have not established any definite criterion of vector abundance by which to judge whether malaria mosquito control work should or should not be undertaken. Rather, our policy is that formulated by Dr. L. L. Williams, Jr., who has stated that each area should be carefully studied in the light of its present and past malaria history and vector abundance, and in the last analysis the decision should depend on the judgment of the investigating officer. In general, where war areas are away from accepted endemic areas for malaria or where the density of the vector is low, or even moderately abundant over intermittent periods of short duration, they should be kept under entomological surveillance only. However, if in such areas there is a general hospital in which troops from the tropics are quartered, we favor active control in order to eliminate any possibility of transmission. An idea of what may be considered a low vector density may be gained from the following quotation from one of Dr. Williams' memoranda.

"I cannot define 'a low density of (*Anopheles*) *quadrimaculatus*.' I have always considered that *quadrimaculatus* is of low density when adults must be searched for carefully and where such careful and prolonged search reveals only a few insects and where no good roosting place contains a greater number of quads than would be counted in 2, 4, 6, or 8; in addition, where there is an absence of *quadrimaculatus* from a number of obviously good roosting places. In my experience where adults are found in the above classification then larvae in the breeding places have never been found in any great quantity. A number of apparently possible breeding places were always found to be free of larvae and where larvae were found they were never continuous, always so-called "spotty" breeding and where spots of larvae were found they were not *easily* found. By that I mean a number of dips in the most favorable local clumps of floatage yield only an occasional larva of *quadrimaculatus*."

We also have no set criterion by which the efficiency of a control job can be judged. The real results of malaria control work in any community of course can only be measured by the decrease brought about in the incidence of that disease or perhaps by the absence of any resurgence during a general cyclic upswing. The part played in malaria control by anti-mosquito measures, however, must be gauged by the degree to which the abundance of the vector species is reduced. Although malaria is at such a low ebb in the United States at present that results in actual disease control cannot be determined suitably, we can determine the reduction in anophelines occasioned and claim results in decreasing the hazard of malaria transmission where our control of the vector species is successful.

As a result of this entomological work, it was determined that during the 1942 mosquito breeding season MCWA controlwork was effective in reducing and maintaining satisfactory low densities of anophelines in approximately 92 per cent of over 900 war establishments protected by the MCWA program. The remaining 8 per cent showed periods during the season when anopheline densities were considered to be sufficiently high to create a potential malaria hazard. This 8 per cent was distributed generally throughout the malaria belt in 12 of the 19 states in which work was undertaken, which indicates that the failures to maintain consistently low populations were caused by local difficulties rather than by general misunderstanding of procedures or technical failures in any one State. Furthermore, our standard of satisfactory control is based on the scarcity of anophelines throughout the entire protected area, and therefore dangerous densities in any one portion would cause the entire zone to be designated as unsatisfactory. A preliminary summarization of our 1943 data shows that the percentage of satisfactorily controlled areas is approximately the same as for 1942. This does not indicate failure to make im-

provement however, because about 250 additional establishments were protected during the current year.

The benefits to our control program from adequate entomological services have been numerous and varied. Projects of little or no merit have been decreased in size or terminated; new projects are undertaken only where sufficient justification can be established; doubtful areas are kept under entomological surveillance until a decision can be made. The savings resulting from this procedure have been considerable and in individual cases have ranged from $10,000 where small projects were concerned, to $100,000 or more where large operations were involved. However, the greatest benefit to the program from entomological services has not been the saving in money, but rather the increased efficiency brought about in the control work. Project supervisors point with pride to their excellent work records and construction jobs, but realize that the real test of this work is the maintenance of low densities of malaria vectors. —12-7-43.

Recent Investigations of Insecticides and Repellents for the Armed Forces[1,2]

E. F. KNIPLING and W. E. DOVE, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Our entry into the present war found our Armed Forces without adequate methods of control for some of the most important arthropods affecting the health of man. During peacetime the necessity of controlling insects and other arthropods of medical importance is generally recognized, but with the beginning of the war the vast movements and large concentrations of troops and civilians have greatly intensified these problems within the United States. Recognition of this domestic situation alone stresses the need for research to develop new or improved control measures for certain disease vectors and noxious species. The worldwide distribution of our troops and civilian war workers, however, has magnified the problems many times. The new combat tactics have outmoded certain methods of control adopted in previous wars, and the problems have been made more difficult by the inadequate supply of pyrethrum and rotenone, which had been counted on to provide means of controlling certain species. In short, means of control were urgently needed for a great majority of the medically important insects and other arthropods throughout the world.

[1] Presented as a part of the Columbus Symposium, 1943.

[2] The data included in this paper were obtained in connection with investigations conducted at Orlando, Fla., under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and the Bureau of Entomology and Plant Quarantine.

The needs for protecting troops and civilians in occupied territories against body lice, transmitters of typhus and trench fever, and from mosquitoes, vectors of malaria, yellow fever, and other diseases, are especially acute. In addition, there is an urgent need for more effective means of controlling other disease carriers, such as houseflies, sandflies, mites, ticks, and fleas.

Three separate projects were organized for the purpose of making investigations on (1) body louse control; (2) repellents for mosquitoes and other flying and biting insects, and for such parasites as mites, ticks, and fleas; and (3) larvicides for the treatment of breeding places of *Anopheles* and other mosquitoes. In conjunction with these projects investigations have been conducted also on insecticides for the control of adult mosquitoes, houseflies, and adults of other disease-bearing insects, as well as certain noxious species, such as bedbugs and cockroaches. This paper presents a summary of some of the more important developments to date.

CONTROL OF LICE AFFECTING MAN.—Army officials considered a powder that could be carried in the soldier's pack to be most desirable for body louse control. Efforts were therefore concentrated on the development of a powder for individual treatment, although studies also were

made with clothing impregnated with lousicides by using suitable solvents.

Since a louse powder was needed as quickly as possible, lousicidal properties of commonly used insecticides were determined in early investigations. These included studies with pyrethrum and rotenone products as well as certain synthetic organic compounds.

Since natural infestations of body lice, *Pediculus humanus corporis* Degeer, are difficult to find in suitable numbers, it was necessary to devise means of testing materials under laboratory and simulated natural conditions. Excellent methods were developed which contributed materially to the rapid progress of the work. The methods used in evaluating these materials have been briefly described by Bushland *et al.*[1] Since large numbers of lice were needed, it was necessary to establish and maintain a large colony of body lice. The methods used in maintaining the colony are described by Culpepper.[2]

The work on the louse project has been aided materially by Dr. W. A. Davis and associates of the Rockefeller Foundation, who evaluated the more effective treatments on large numbers of natural infestations.

Several hundred synthetic organic compounds were tested under laboratory conditions during the first few months after investigations were initiated. Coincident with these studies, tests with pyrethrum and rotenone products were in progress. Rotenone and pyrethrum in the early tests showed most promise for the development of suitable louse treatments at concentrations that were thought to be safe for applications to the body.[3]

A number of comparative tests indicated that, when impregnated on pyrophyllite, pyrethrins and rotenone (from derris or cube resinates) were about equal in their lousicidal value. Pyrethrum seemed most suitable because of its more rapid insecticidal action and because no physiological reactions were noted on research subjects. The rotenone powders, on the other hand, caused scrotal dermatitis in a high percentage of subjects when 1 ounce of the powder was applied inside the undergarments.

To improve the effectiveness of pyrethrins, investigations were made with several pyrethrum synergists. Because their value had been proved in fly sprays, sesame oil, *D.H.S. Activator*, and N-isobutylundecyleneamide were among the first of approximately 300 synergists tested. The first two materials showed only slight synergistic properties at concentrations of 2 per cent in dusts containing pyrethrins. On the other hand, the N-isobutylundecyleneamide showed remarkable synergism for pyrethrins against the body louse. The synergistic action of this material allowed the use of pyrethrins in a 0.2 per cent concentration, and the resulting formula proved more effective than 1 per cent of pyrethrins without an activator.

Since pyrethrum and rotenone are not ovicidal, various synthetic organic compounds were tested as ovicides. Among the effective materials, 2, 4-dinitroanisole seemed most promising.

On the basis of these studies a formula (MYL formula) was recommended to the Office of Scientific Research and Development in August 1942. The powder is composed of 0.2 per cent of pyrethrins (using a 20 per cent pyrethrum concentrate), 2 per cent of N-isobutylundecyleneamide, 2 per cent of 2, 4-dinitroanisole, and 0.25 per cent of *Phenol S* (anti-oxidant) in pyrophyllite. Details of the tests leading to the formulation of this powder and results of tests are discussed in the paper by Bushland *et al.*[1] The MYL formula in comparative tests proved more effective against the body louse than other louse powders known to the investigators. It also proved effective in controlling the crab louse, *Phthirus pubis* (L.), and the head louse, *Pediculus humanus humanus* L.

REPELLENTS FOR MOSQUITOES AND OTHER FLYING AND BITING INSECTS.—The project on insect repellents is designed to evaluate repellents for a variety of bloodsucking insects and arthopods, other than lice, of importance to the

[1] Bushland, R. C., L. C. McAlister, Jr., G. W. Eddy, Howard A. Jones, and E. F. Knipling. 1943. A powder treatment for the control of lice attacking man. (Unpublished.)

[2] Culpepper, G. H. 1943. The rearing and maintenance of a laboratory colony of the body louse. (Unpublished.)

[3] Some observations on physiological effects on man of the various insecticides tested were made in connection with the investigations at Orlando, Fla. However, all promising materials that were considered for practical applications have been submitted to H. O. Calvery and associates, of the Food and Drug Administration, for toxicological tests. Toxicological tests were also made by M. I. Smith, Division of Chemotherapy, and P. A Neal and W. F. von Oettinger, Division of Industrial Hygiene, National Institute of Health, U. S. Public Health Service. The work of these toxicologists has been an essential and highly important phase of the investigations.

Armed Forces, such as mosquitoes, biting flies, sandflies, and other flying and biting insects, as well as mites, ticks, and fleas. The primary objective is to develop materials that can be applied by the individual soldier for protection against the insects and arthopods mentioned. In many cases the control of mosquitoes or other insects by the chemical treatment or destruction of the breeding areas is not feasible. The use of repellents or insect nets is the only feasible means of protection.

Of the various disease vectors considered in connection with this project, most emphasis has been placed on the development of repellents for *Anopheles* and other mosquitoes.

Citronella was the only well-known and widely used insect repellent at the time of our entry into the war, although many other repellents were being sold to the general public. The first objective was to evaluate as many materials as possible for the purpose of recommending a satisfactory repellent that could be supplied for military use at the earliest possible date. A repellent was developed which after careful research proved to be among the best in use. However, this material was tested by H. O. Calvery and associates of the Food and Drug Administration and was found to be too toxic for use under military conditions.

Tests of mosquito repellents were made under laboratory conditions, using *Aëdes aegypti* (L.), *Anopheles quadrimaculatus* Say, and *Stomoxys calcitrans* (L.), The technique employed was a slight modification of that devised by Granett (1940). The more promising repellents were evaluated in the field against *Aëdes taeniorhynchus* (Wied.) and *A. sollicitans* (Walk.) In addition to tests by B. V. Travis and associates of the Orlando station, various individuals and agencies have cooperated in testing repellents against other species in different parts of the world.

On the basis of early tests, three safe repellents were found to give good protection against *Aëdes* mosquitoes, and these were recommended for use by the Armed Forces. Details of the results are given in a manuscript by Travis and Smith,[1] which has been prepared for publication.

The repellents recommended are dimethyl phthalate, *Rutgers 612*, and *Indalone* Dimethyl phthalate had been found by the Orlando workers to be a good flea repellent. Later it was learned that the chemical had been sold as a repellent by the Standard Oil Company as a 25 per cent solution in alcohol. *Rutgers 612* was found by P. Granett to be effective against *Aëdes aegypti* in laboratory tests, and *Indalone*, supplied by Kilgore Development Co., was one of the more effective repellents against flies.

These repellents under experimental laboratory and field conditions will protect against *Aëdes aegypti* and *A. taeniorhynchus* for from 3 to 5 hours, on the basis of complete protection to the first bite. Rutgers 612 has proved most effective against *Aëdes*, whereas dimethyl phthalate is most effective against *Anopheles quadrimaculatus*. *Indalone* is of little value as a repellent for *A. quadrimaculatus*, whereas it is the most effective of the three against *Stomoxys calcitrans*.

It has been found that the repellents mentioned remain effective for a much longer period on clothing than when applied to the skin. When sprayed on a suit of clothing at the rate of from 50 to 100 cc., protection from *Aëdes taeniorhynchus* was obtained for a period of about 1 week. Similar results were obtained with *Aëdes aegypti* and *Anopheles quadrimaculatus* in laboratory tests. Since mosquitoes readily bite through clothing, the treatment of clothing is important and will provide much more complete protection than skin treatment alone.

Results of tests with the three repellents mentioned, as well as with many other materials, emphasize the importance of testing materials against a variety of species. Individual variation in the protection afforded by different repellents on different subjects is also an important factor. Other considerations are important in evaluating a repellent, such as conditions under which the user is living. The repellents in general prove much less effective when users are under exertion and are perspiring freely. The relative effectiveness of different repellents on the basis of partial protection after some mosquitoes begin biting is also important.

CHIGGER-REPELLENT INVESTIGATIONS.—Investigations on the development of treatments for protecting military personnel from chiggers have been presented in a paper by Madden *et al.* (1944). Aside

[1] Travis, B. V., and A. L. Smith, 1943. Tests of three insect repellents used by the Armed Forces. (Unpublished.)

from the importance of chiggers, *Eutrombicula* and *Acariscus* spp., in causing extreme irritation which frequently leads to secondary infections, they also are important in the transmission of a typhus-like disease in certain foreign countries where our troops are located.

Various insecticides and repellents were tested as a chigger prophylaxis. These included sulphur, derris, rotenone, and pyrethrum. These materials in powder form did not provide adequate protection when the test subjects sat or crawled about in infested areas. The results were generally erratic, and treatments did not last as long as desired. The application of liquid repellents such as dimethyl phthalate, *Indalone*, and *Rutgers 612* to the legs and arms provided good protection for periods of short duration.

The most effective means of protection from chiggers was found to be the application of liquid repellents to clothing. Clothing can be sprayed with repellents or dipped into repellent solutions with effective results. The simplest method of treatment, however, consists in the application of a repellent barrier on the socks, cuffs of trousers, leggings, sleeves, and other openings in the clothing where chiggers may crawl through. This can be done without special equipment by using the bottles of repellents issued for military personnel. A thorough treatment as described, which requires about 1.5 to 2 ounces, will protect the individual from chigger attack for a week or more, or until the clothing is removed for laundering. Of the three repellents mentioned above, dimethyl phthalate is considered most effective and desirable.

Tests of repellents were also made against ticks by using the same materials and methods that proved effective against chiggers. The powders in general proved unsatisfactory. The liquid repellents applied to clothing proved effective against larval and nymphal ticks of *Amblyomma americanum* (L.), but results against adult ticks were in general unsatisfactory.

FLEA REPELLENTS.—Tests of flea repellents were conducted in a manner similar to that used in testing mosquito repellents. A reared mixed culture of the dog flea, *Ctenocephalides canis* (Curtis), and the cat flea, *C. felis* (Bouché), was used, and these species proved satisfactory for the purpose. The oriental rat flea, *Xenopsylla cheopis* (Rothsch.), proved unsatisfactory as a test species, since it did not readily bite in captivity.

Although a number of repellents were tested, the three materials dimethyl phthalate, *Indalone*, and *Rutgers 612* provided several hours' protection when applied to the skin. Preliminary tests indicate that the application of the repellent to clothing will provide protection for several days.—1-28-44.

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Population Studies of Florida Mosquitoes

V. G. DETHIER[1] and F. H. WHITLEY[2]

In the course of a mosquito-survey conducted by the United States Army near Tampa, Florida, considerable data was gathered on the frequency and seasonal distribution of the more common and economically important species. The nature and extent of the collections from which these data were derived permit of a more complete study of population densities and fluctuations than was heretofore possible in this section of Florida. Daily light-trap, biting, and resting collections as well as collections of larvae were made over a period of 20 months. Meteorological data were also obtained for the same period.

The area under consideration is a peninsula near the city of Tampa comprising approximately 10 square miles. A fringe of mangrove characterizes the coastline. Inland from this are grassy salt marshes. The greater part of the area supports a flora represented predominantly by palmetto and scattered stands of pine. Ap-

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proximately 172 more or less permanent bodies of water dot the peninsula. These include a small number of fresh water ponds, overgrown ditches and borrow pits containing salt, fresh, or brackish water, grassy swales in which rain accumulates, and salt marshes. Each body of water, whether permanent or otherwise, was catalogued and a complete record of its larvae content maintained. Six New Jersey type traps were erected, one each in the north, northeast, east, south, west, and the northwest portions of the field. Biting and resting mosquitoes were collected in the usual manner. In addition three animal-baited traps were maintained. Mosquitoes were identified by members of the Fourth Service Command Laboratory and the United States Public Health Service Malaria Control in War Areas.

Altogether 27 species were collected during the 20-month period over which this survey was conducted (Table 1). For the year 1942 data on the frequency of species agree very closely with those of those of other surveys in the southeastern states. For example, the six most common species collected by Fisk & LeVan (1940) during a survey near Charleston, S. C. from August to October appeared in our collections in essentially the same order of abundance: *Aëdes taeniorhynchus* > *Melanoconion* > *Uranotaenia sapphirina* > *U. lowii* > *Aëdes sollicitans* > *Anopheles crucians*. The most notable difference between the two sets of data is the large number of *Psorophora columbiae* taken in the present survey. This species together with *A. taeniorhynchus* and *A. sollicitans* occurred in such large numbers over an extended period as to necessitate the initiation of extensive control measures. Second only to these in importance were *Aëdes mitchellae*, *Anopheles crucians*, *Culex salinarius*, and *Mansonia perturbans*.

For the year 1943 the seven most common species were *Psorophora columbiae* > *Aëdes taeniorhynchus* > *Culex nigripalpus* > *Anopheles atropos* > *Aëdes sollicitans* > *Melanoconion* > *Uranotaenia sapphirina* (Table 1). During this season *P. columbiae* far outnumbered any other species, there being approximately twice as many taken as of the next most abundant species, *A. taeniorhynchus*. From the standpoint of biting the same three species top the list each year, *A. taeniorhynchus*, *P. columbiae* and *A. sollicitans*.

Numerical abundance was directly influenced by three factors: rainfall, air temperature, and wind velocity. Excessive rainfall, especially in the form of tropical storms, caused a pronounced reduction in the number of adults taken at light traps. Lack of rainfall, on the other hand, resulting in a more or less prolonged drought also affected population density by permitting most pools of fresh and brackish water to dry. Dry periods were invariably followed by a reduction in the number of adults normally breeding in such habitats. Wind speeds in excess of 10 mph. reduced the flying population. Fluctuations of temperature did not affect the flying population so profoundly as was expected; however, temperatures above 70° F. appeared to be optimum.

Table 1.—Relative abundance of mosquitoes taken by light-traps during the years 1942 and 1943.

SPECIES	NUMBER AND RANK 1942	1943
Aëdes taeniorhynchus	7148—1	15678—2
Melanoconion	3717—2	726—6
Psorophora columbiae	2920—3	3508—1
Uranotaenia sapphirina	2667—4	321—7
Anopheles atropos	1920—5	1609—4
Aëdes mitchellae	1728—6	306—8
Aëdes sollicitans	1242—7	1283—5
Culex salinarius	687—8	126—12
Anopheles crucians	395—9	201—9
Mansonia perturbans	284—10	10—20
Culex pilosus	260—11	115—13
Uranotaenia lowii	218—12	91—14
Culex quinquefasciatus	195—13	127—11
Culex nigripalpus	179—14	1750—3
Theobaldia inornata	75—15	45—16
Aëdes infirmatus	57—16	130—10
Culex apicalis	27—17	5
Psorophora ciliata	21—18	61—15
Theobaldia melanura	11—19	3—23
Anopheles quadrimaculatus (biting collections)	11—20	3—23
Aëdes vexans	5—21	19—17
Culex erraticus	3—22	17—18
Mansonia titillans	2—23	—
Anopheles walkeri	—	1—25
Culex restuans	1—24	—
Aëdes atlanticus	1	14—19
Aëdes aegypti (larvae only)	1	—
Psorophora ferox (resting collections)	1	7—21
Aëdes canadensis	—	7—21

The value of a 2-year survey of this sort lay in the possibility of more readily recognizing the direct influence of variables such as temperature, rainfall, etc., and by thus recognizing these, obtain a more accurate picture of overall seasonal distri-

bution. The limitations of the light trap method of sampling were fully appreciated; therefore, data so obtained were correlated with data obtained by other methods. Interpretations are based on the relation between catches by the different standard methods of collecting. This relation is considered in the following notes on each of the species taken.

Aëdes taeniorhynchus (Wied.).—By far the most abundant and annoying mosquito throughout the year 1942 was this salt marsh species. Approximately 8000 specimens were taken in the light traps. While this total does not even approximate that reported by King *et al.* (1942), it nevertheless indicated that this species existed in enormous numbers. During 1943 more than fifteen thousand specimens were taken from January to August. Although it was especially annoying from dusk to dawn and at times made sentry duty almost unbearable, it also plagued troops maneuvering in mangrove swamps and other shaded areas during the day. The advent of annoying densities occurred about the beginning of April with peak numbers appearing in June and July. A gradual decrease beginning in August continued throughout November. During the winter and early spring *A. taeniorhychus* was never encountered in pest proportions. In short, the season of greatest density extends from April to August. Great fluctuations during this period are due to varying meteorological conditions.

Most of the breeding on the peninsula took place in residual pools of salt and brackish water following exceptionally high tides which flooded overgrown ditches and borrow pits. Pools in salt marshes also harbored larvae throughout the year.

Aëdes mitchellae (Dyar).—This species was by no means rare during the year 1942 but was of less common occurrence the following season. In the first case it ranked second to *Aëdes taeniorhynchus* (as regards this genus) in numbers collected. With the exception of tremendous numbers collected during March and April it did not constitute a major problem. During the peak season, however, it was frequently taken in biting collections. Larvae were collected during the summer, early fall, and mid-winter in temporary fresh water pools and to some extent in permanent fresh water ponds also. During 1943 an increase in numbers was noted in June and July. The season of greatest abundance probably extends from April to July.

Aedes sollicitans (Walk.) (Fig. 3).—During both years *Aedes sollicitans* was especially annoying from April to early July when it attained greatest numerical proportions. The large numbers encountered in January and February of 1942 were not in evidence during the corresponding period of 1943. From October through January numbers were small though biting collections consisted largely of this species during the winter months. It was one of the most serious of the daytime pests. Together with *A. taeniorhynchus* it made outdoor night work well nigh impossible during the early summer. As might be expected, breeding occurred in salt marshes and man-made depressions subject to infrequent tidal action and generally in the same locations as *A. taeniorhynchus*. Larvae were numerous throughout the season.

Aëdes infirmatus D. & K.—Fifty-six specimens were collected from light traps during 1942. The following year this species ranked tenth in numbers taken. The greatest concentration in the first instance occurred during April at which time several specimens were also taken in biting collections. The 1943 peak was during June and July. This and the following species were found breeding during the spring in stump holes.

Aëdes vexans (Meig.).—Three specimens came to light during August of 1942. The greatest number any one month was eight collected June 1943.

Aëdes atlanticus D. & K.—One specimen was taken at light in September 1942. Of 14 collected in 1943 8 were taken in July.

Aëdes canadensis (Theob.).—A single specimen was taken the third week of August 1943.

Aëdes aegypti (L.).—No adult specimens were captured on the peninsula, but in early September 1942 large numbers of larvae were discovered in water barrels adjacent to barracks.

Psorophora columbiae (D. & K.).—Next to *Aëdes taeniorhynchus* and *A. sollicitans* this was the most prevalent pest mosquito encountered in 1942. In all, 2920 individuals were taken at light-traps. In 1943 a total catch of over thirty thousand placed it at the head of the list. From May to

October inclusive the species was exceedingly common. During the remainder of the year it occurred sporadically. Greatest numbers were recorded in June and July. At this time of year it is most annoying.

Larvae were found abundantly from April to the end of October and sporadically during the winter. Breeding was most prolific in weedy trenches, old ditches, stump holes, fox holes, and temporary ponds.

Psorophora ciliata (F.).—With the exception of occasional specimens taken from the latter part of April to the end of October, this large mosquito was of little importance. Twenty-one individuals were taken in light-traps and an equal number in biting collections in one year; 61 individuals, the following year, mostly in July. Larvae were not uncommon in the same spots harboring the preceding species during the same period.

Psorophora ferox (Humb.).—A single specimen was captured during the week of March 22, 1943 and seven during July 1943.

Anopheles atropos D & K.—In light-trap collections this was the predominating anopheline. Its season begins in May and terminates toward the end of September. From June to July large numbers were taken. Few were captured through the balance of the year. The species was also quite common in biting collections. Occasional larvae were secured throughout the year in small salt water ponds. The number of larvae found was never proportional to the number of adults captured. The peak collection of January 1942 was not duplicated in 1943.

Anopheles crucians Wied.—No attempt was made to separate *A. crucians* from *A. bradleyi* King and *A. georgianus* King. A total of 596 specimens of the *crucians* group was captured in light-traps. These species, though not especially abundant, were found commonly throughout the year but in greater numbers during April, July, and August. On account of their propensity for entering buildings at night they were especially annoying. Also, they were always found in biting collections. Breeding was prolific more or less continually in several permanent fresh water ponds and in one or two temporary grassy ponds.

Anopheles quadrimaculatus Say.—Only 14 individuals were taken during the entire 20 months. Of these 11 were captured in biting collections. This species was not at all common in any collections. A few larvae were found in overgrown ditches containing fresh water. None was found in bodies of fresh water harboring. *A. crucians.*

Anopheles walkeri Theob.—A single specimen was taken during the first week of July 1943.

Melanoconion.—Within this subgenus are but two common Floridan species, *Culex erraticus* D. and K. and *Culex pilosus* (D. and K.). Of the numbers taken those males that were in good condition were determined by examination of the genitalia. Of those so examined in 1942, 260 were *C. pilosus* and 3, *C. erraticus;* in 1943, 115 were *C. pilosus* and 17, *C. erraticus. Melanoconion* adults first appeared in numbers in June, and large catches persisted through October. They were of sporadic occurrence only during the balance of the year. Few were taken in biting collections. Larvae of *C. erraticus* were the most common mosquito species found on the peninsula; prolific breeding was in evidence in nearly all temporary bodies of fresh water as well as in the permanent ponds that containing *Anopheles crucians.*

Culex salinarius Coq.—Aside from the foregoing species, *Culex salinarius* was the most frequently encountered member of the genus during 1942. It was a constant component of biting collections and commonly entered barracks at night. Peak appearances characterized mid-winter, early spring, and late fall, the greatest abundance being in the fall. Larvae were found throughout the year in more or less permanent fresh water, grassy ponds and also in man-holes, water barrels, ditches, and fox holes. It was much less common in 1943.

Culex quinquefasciatus Say.—This domestic mosquito was not nearly so abundant as was to be expected in an area which offered so many characteristic breeding spots. Few individuals were taken in biting collections though large numbers of larvae were observed from time to time in water barrels, polluted puddles, and trenches. Adults came to traps in small numbers all year. Small peaks appeared in May both years and early in August and November of 1942.

Culex nigrapalpus Theob.—This was the most common *Culex* of 1943. Appreci-

able numbers came to light from June to November of both years. The peak season is clearly June to October. Though also taken in biting collections, the species was not so annoying as *C. salinarius*. Larvae were almost as common as those of *C. erraticus*, and both were found in the same bodies of water.

Culex apicalis Adams.—A total of 32 individuals was taken at light-traps. The species was found sporadically throughout the year.

Culex restuans Theob.—A single specimen was taken in the second week of May 1942.

Uranotaenia sapphirina (O.-S.).—Adults of this species were the fourth most abundant encountered in light-trap collections during 1942. The following year they fell to seventh place. Many were also taken in the grass adjacent to small pockets of fresh water bordering swamps. Larvae were numerous in these puddles. Adults were found all year. The peak numbers of April 1942 were not duplicated in 1943. The season of greatest abundance extends from the end of August till October. During the summer comparatively few individuals are found.

Uranotaenia lowii Theob.—By no means as common as the foregoing species, this mosquito came to traps only from April to May and August to November. Greatest numbers were recorded in August–September. None was taken in resting or biting collections. Larvae were found with those of *U. sapphirina*.

Mansonia perturbans (Walk.).—Although this mosquito was taken frequently in biting collections and was a frequent visitor in barracks after dark, it was not one of the most serious of pests either year. Taken at lights in 1942 were 284 individuals but the catch fell to 10 the following season. The record of seasonal abundance on the basis of 1942 collections agrees with the statements of King, *et al.* Adults were taken from the last week in March to the third week in November. The greater peak occurred in April and May and a lesser one in October. Despite a thorough examination of the area, breeding was located in one small pond only, where the host plant was pickerelweed (*Pontedaria cordata*). Larvae were found the entire year. Inasmuch as this pond was completely eliminated in the winter of 1942 it is believed that the small catch the following year was due to this factor rather than to natural causes.

Mansonia titillans (Walk.).—Two adults only were taken and these at light during the last week of October 1942.

Theobaldia inornata (Will.).—Adults were taken from the last week of October till the end of February only, with the peak of abundance coming in December and January. Only 75 specimens were collected in 1942 and 45 in 1943. Breeding occurred especially during the winter in fox holes, temporary ponds, and occasionally in larger fresh water ponds.

Theobaldia melanura (Coq.).—Fourteen specimens were collected throughout the entire 20 months. These were evenly scattered from February through October.—12-21-43.

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E. DWIGHT SANDERSON—1878–1944

Dr. Dwight Sanderson, better known to his entomological colleagues as "E. Dwight," died in Ithaca on September 27 from a heart attack. He was 66 years old.

Dr. Sanderson was active in the Association for many years and served as its President in 1910. For nearly thirty years he has been working in the field of Rural Sociology and, particularly, Rural Organization. An extended account of his career will be published in our October number.

The Use of Repellents Against Fleas.[1]

ARTHUR W. LINDQUIST, A. H. MADDEN, and C. N. WATTS,[2] *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Fleas are not only annoying pests of man, but some species are also disease vectors. The oriental rat flea, *Xenopsylla cheopis* (Rothsch.), for example, has been definitely implicated with the spread of plague. In the pursuit of global war members of the armed forces must inevitably become exposed to flea attack. Where operations are of a temporary nature or other factors prevent control measures or make them impracticable, the use of repellents would serve as a satisfactory substitute. In 1942 studies were undertaken at Orlando, Fla., for the purpose of discovering repellent materials that would protect the individual against these insects. Approximately 1800 tests were conducted with the sticktight flea, *Echidnophaga gallinacea* (Westw.), and the dog and cat fleas, *Ctenocephalides canis* (Curtis) and *C. felis* (Bouché).

METHODS.—In the initial tests repellent materials were applied to the heads of white leghorn chickens exposed to heavy infestations of fleas, particularly the sticktight flea. Materials were evaluated by comparing the number of fleas on treated and untreated chickens. However, since the results eventually would have to be checked on man, tests with human subjects were undertaken.

A mixed culture of 500 to 1000 dog and cat fleas was maintained in a small cage into which a treated arm could be placed. One milliliter of the material to be tested was rubbed on the skin from wrist to elbow of colored and white test subjects, and at intervals of 15 to 30 minutes the arm was exposed to the fleas. The time between applications of the treatment and the first bite was recorded. No repellent was found that would prevent fleas from jumping onto the arm, but any repellent substance, while it was still effective, caused them to leave immediately. Because the flea is not deterred from jumping onto the treated arm, many cages were necessary in order to provide a continuous supply of specimens unaffected

Table 1.—Results of tests with repellents against dog and cat fleas.

MATERIAL	NUMBER OF TESTS	REPELLENT PERIOD IN MINUTES	
		Range	Average
Pyrethrins 1%+*IN-930* (N-isobutylundecylenamide) 2% in mineral oil (342 seconds Saybolt at 100° F.)	16	346–515	435
2-Ethylhexyl ether of diethylene glycol	8	220–549	398
n-Hexyl ether of diethylene glycol	8	237–494	388
Pyrethrins 1% in dimethyl phthalate	17	98–512	337
n-Butyl *dl*-malate	3	224–385	293
Dimtehyl phthalate	28	42–535	260
Propylene glycol ether of "dibutanol"	4	76–397	254
Rotenone 0.2%+N-amyl-2,4,5,6-tetrachlorophenoxyacetamide 1.8% in *Indalone* (n-butyl mesityl oxide oxalate)	2	200–304	252
n-Butyl salicylate	1	—	235
Methyl o-methoxybenzoate	1	—	234
Amyl salicylate	10	135–384	232
Pyrethrins 40 mg.+*IN-930* 420 mg. in 100 ml. of white oil (100 seconds Saybolt at 100° F.)	8	125–390	228
Cyclohexyl ether of dipropylene glycol	9	125–325	228
Rotenone 0.2% in N-amylbutoxyacetamide	3	110–440	225
D.H.S. Activator (ethylene glycol ether of pinene)	5	150–345	223
alpha-n-Amylcinnamaldehyde	2	140–305	222
N-Amylbutoxyacetamide	3	147–290	221
N-Cyclohexylbutoxyacetamide 33.3% in *Indalone*	2	197–241	219
Cottonseed nitrile	4	185–266	219
Pyrethrins 1%+*IN-930* 2% in *Indalone*	21	60–370	194
Oil of thyme	8	87–477	192
Dipropylene glycol ether of "dibutanol"	7	55–275	188
Benzyl salicylate	2	174–200	187
N-Amyl-2,4,5,6-tetrachlorophenoxyacetamide 2% in N-amylbutoxyacetamide	2	57–316	186
Undecalactone (peach aldehyde)	3	129–215	182
3,3,5-Trimethylcyclohexyl ether of diethylene glycol	5	62–235	181
Cyclohexyl ether of diethylene glycol	4	84–238	172
n-Butyl o-formate	1	—	165
Indalone	9	60–285	160
4-tert-Amylcyclohexanol	5	102–237	160
Dibutyl phthalate	5	105–237	159
alpha-Methylbenzyl ether of propylene glycol	5	107–211	157
Isoamyl salicylate	13	90–224	153
2,5-Endomethylene-6-methylhexahydrobenzyl ether of diethylene glycol	3	106–178	152
Ethyl adipate	12	116–169	146
Rutgers 612 (2-ethyl-1,3-hexanediol)	32	50–333	139
Oil of citronella	12	71–216	138
Ethyl cinnamate	3	130–144	135
Carbitol phthalate	3	65–235	125
Butyl ether of polypropylene glycol	2	101–143	122
Sta-Way insect repellent lotion[1]	6	100–136	122
Lauryl alcohol	4	80–177	120
Propylene glycol ether of 2-methyl-2,4-pentanediol	4	78–186	116
Methyl sebacate	1	—	115
Amyl phthalate	12	42–197	115
Lauronitrile	4	90–136	104

[1] Active ingredients are diethylene glycol monobutyl ether acetate and diethylene glycol monoethyl ether.

[1] This work was conducted under a transfer of funds, recommended by the Committee on Medical Research, from the Office of Scientific Research and Development to the Bureau of Entomology and Plant Quarantine. The writers wish to acknowledge the assistance of H. A. Jones on the chemical aspects of the problem.

[2] Enlisted in the United States Marine Corps, Sept. 15, 1942.

by contact with the chemicals. For this reason fleas are not very satisfactory insects for use in testing repellents under laboratory conditions.

Later tests were conducted with subjects wearing treated clothing in buildings heavily infested with fleas.

RESULTS.—Some of the most promising results of the laboratory tests on human subjects are summarized in table 1. The longest average protection time was obtained with a mixture containing 1 per cent of pyrethrins and 2 per cent of *IN-930* in mineral oil. However, because of the scarcity of pyrethrum this mixture could not be considered for practical use. It is probable that pyrethrum combinations were actually toxic, rather than repellent, and caused a knockdown of the fleas that came in contact with them. Several other materials including 2-ethylhexyl ether of diethylene glycol, n-hexyl ether of diethylene glycol, and propylene glycol ether of "dibutanol," were found to be very satisfactory repellents, but because of unavailability or for toxicological reasons they cannot be recommended. Dimethyl phthalate, *Rutgers 612*, and *Indalone* also were effective, and since they have been adopted by the armed forces as repellents for other insects, they are available for military use in the field. The average duration of repellent time was nearly twice as long with dimethyl phthalate as with the other two materials.

Tests with treated clothing show that any of these three repellents used on the clothing will give protection against fleas for several days. From 100 to 150 ml. is sprayed on the socks and trousers. It is recommended that this treatment be applied before troops enter infested areas or buildings.

SUMMARY.—Initial tests of flea repellents were made by exposing treated chickens to high flea populations, but this method was soon discarded in favor of tests conducted with human subjects, The treated arm was exposed in cages containing from 500 to 1000 fleas, and the time between treatment and the first bite was recorded. The longest average protection time was obtained with a mixture containing 1 per cent of pyrethrins and 2 per cent of *IN-930* in mineral oil, but this mixture would at present be unavailable for practical use because of the scarcity of pyrethrum. Dimethyl phthalate, *Rutgers 612*, and *Indalone* were found to be very effective, giving an average repellent period of 139 to 260 minutes. These materials are available for military use in the field. Dimethyl phthalate gave the longest repellent time of the three. Clothing treated with these repellents will give protection from flea attack for several days.—7-19-43.

Bordeaux Formulae and Potato Insect Control

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Bordeaux mixture is the most commonly used spray and dust material recommended for pest control on potatoes grown in New York. This copper fungicide applied at frequent intervals during the growing season is necessary for protection from infections of the late blight fungus, *Phytophthora infestans*. Due to its repellent properties, bordeaux is also very effective for preventing damage by the flea beetle, *Epitrix cucumeris* and the leafhopper, *Empoasca fabae*.

Experiments conducted over a period of many years by numerous workers have shown the value of using bordeaux mixture. In years when late blight is epidemic this is unquestioned. Even in seasons when late blight is absent, profitable increases in yields have been obtained from spraying or dusting with bordeaux. Such increases during non-blight years are usually attributed to control of flea beetles and leafhoppers. Mader & Blodgett (1935), questioned this explanation and contended that some of the increase in yield was due to a stimulation of the potato plants by copper. They believed that a minute quantity of soluble copper was

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[2] With the U. S. Public Health Service.

absorbed into the plant tissue and physiologically stimulated foliage growth and tuber production.

Mader & Blodgett based their conclusions on several years work in southern Monroe County near Rochester. Their experimental results showed that insect injury could not be directly correlated with variations in yield obtained by using different bordeaux formulae or modified spray programs. For instance, it was found that a low lime formula (1 copper sulphate: 0.5 hydrated lime) was superior from the standpoint of yields to a high lime formula. Since the amount of insect injury indicated as tipburn was the same regardless of formula used, Mader & Blodgett concluded that "the tendency for the mixtures with smaller excesses of lime to give higher yields is attributed to the greater solubility of copper in these mixtures." Further, it was found that modifying the spray schedule by decreasing the concentration of bordeaux from heavy, 10-5-50,[1] to light, 2-1-50, as the season progressed increased yields more than the reverse, 2-1-50 to 10-5-50, or a schedule using a 5-2.5-50 formula. Equal amounts of copper sulphate were applied throughout the season in the bordeaux with each schedule. The reason for the yield differences between schedules was thought to be due to differential effects of copper stimulation during the growing season. With the "high-low" schedule the plants were stimulated early in the growing season to abundant foliage growth which, in turn, was reflected in tuber yields. When most of the bordeaux was applied late in the season, the plants were stimulated to excessive top growth at the expense of tuber production.

A low-lime bordeaux mixture and a "high-low" schedule have been recommended for a number of years with considerable success. However, it was apparent in some potato growing areas of the state that the low lime formula was inadequate for proper protection against flea beetles and leafhoppers. These insects were generally of more importance than late blight.

A series of spray experiments was started during the season of 1940 in southern Erie County, near Buffalo, where growers were having considerable trouble with flea beetles and leafhoppers. The field work has been supplemented by experiments conducted in the insectary. The objectives of this work were to establish the value of bordeaux mixture as a repellent to flea beetles and leafhoppers and to determine a formula suitable for satisfactory control of these insect pests.

In both greenhouse and field experiments the bordeaux formula was varied by changing the content of copper sulphate and hydrated lime. The amounts of lime were varied from 1–50 to 8–50 and the copper from 2–50 to 8–50. In the field it was deemed unwise to reduce the copper sulphate content to less than 4–50 due to the ever present possibility of epidemic late blight infections.

Potted single-stalked plants of the Green Mountain variety with 8 to 10 fully expanded leaves were selected for the insectary experiments. The plants were prepared by cutting off the growing tip and pinching back all lateral shoots. Only plants of the same size and vigor were selected for a particular experiment. These were completely randomized before being sprayed in a precision insectary sprayer. After thoroughly wetting the leaves with the spray the plants were allowed to dry and were then placed in a greenhouse in the presence of a large number of flea beetles. Following several days exposure to the flea beetles, the plants were examined and the number of feeding holes in each leaf were counted.

The field experiments were performed in commercial plantings using a power sprayer carrying a six-row boom with three nozzles for each row. Spraying pressure and delivery rate were maintained at approximately 400 pounds and 110 gallons per acre respectively. Plots were randomized within four blocks in each experiment except the one conducted in 1940. In the latter case a restricted design was used to facilitate the spraying operation. No apparent bias was introduced by this restriction. Untreated plots have not been included in the experimental blocks since the value of spraying is well established and the loss to the grower from untreated plots is undesirable. Two small untreated strips between blocks of sprayed plots have each year given adequate proof of the value from spraying.

Flea beetles and leafhopper populations were random sampled by net sweeping at

[1] 10-5-50 = 10 lbs. copper sulphate, 5 lbs. hydrated lime to 50 gals. of water.

various stations in each plot. Injury was scored by counting flea beetle feeding holes in a unit area of leaves picked at random throughout each plot. Leafhopper injury was difficult to determine quantitatively because the injury is evident in so many forms from hopperburn to leaflet curl. The number of leaflets injured by leafhoppers was recorded from a sample of leaves taken from each plot and the injury is expressed on a percentage basis. These methods used for the insect data seemed to be adequate. Sampling the insect population in the case of these experiments was unnecessary since the chief interest centered on the amount of damage caused by the insects. Due to migration from plot to plot it was evident that injury would be a better indicator of control than insect population.

Table 1.—A comparison of the repellency to flea beetles and leaf hoppers of bordeaux and hydrated lime in small field plots.

		Flea Beetle Feeding Holes per Unit Area of Foliage	Per Cent of Leaflets Injured by Leafhoppers
Bordeaux 4-8-50		39.4	30.4
Hydrated lime 8-50		64.0	35.4
Unsprayed		88.3	82.6
Least difference for significance	5%	15.3	9.0
	1%	23.1	13.6

Tuber yields were taken from 0.01 acre row strips in each of the six rows of the plot. The sampling area was selected in the part of the field where the soil appeared to be most homogeneous. However in this type of field experiment each block covers a considerable area of the field and soil variation is likely to be quite large. In summarizing the data the analysis of variance has been used.

Insectary Tests.—One of the properties of bordeaux as a protectant against injury by flea beetles and leafhoppers is its repellency. The spray or dust coating prevents or deters these pests from feeding on treated foliage. However, the repellent value of bordeaux seems to vary according to the formula used. In practice the mixture is made with an excess of hydrated lime. The amount of copper sulphate as well as the hydrated lime may be varied within limits and the character of the spray coating may be changed accordingly. In the insectary tests the objective was a study of changes in the repellency of bordeaux when the components, copper sulphate and hydrated lime, were varied.

In the first of a series of experiments, hydrated lime was compared with bordeaux using equal quantities of lime in each comparable spray. Three levels of hydrated lime were used and in case of the bordeaux the levels of copper sulphate and lime were equal in each combination of the mixture.

The data are reported graphically in figure 1 showing the relation of the number of flea beetle feeding holes to the concentration of spray. Concentration increments of both hydrated lime and bordeaux gave increased protection, but the latter spray was significantly more effective than hydrated lime. The superiority of the bordeaux may be due in part to differential deposition of the two sprays. The bordeaux seemed to be more adhesive than hydrated lime and less of the bordeaux dripped from the foliage than in case of the lime.

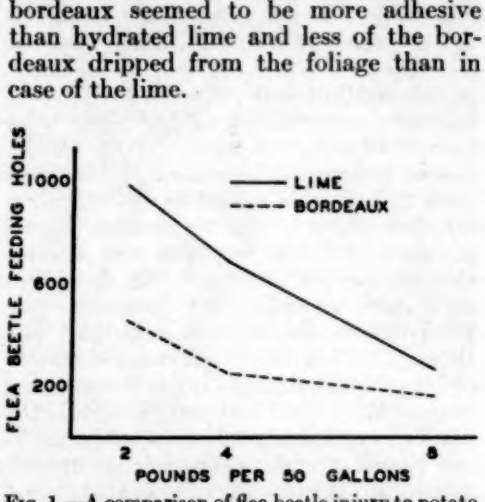

Fig. 1.—A comparison of flea beetle injury to potato plants sprayed with bordeaux and hydrated lime. For each increment the bordeaux was made with equal amounts of copper sulphate and hydrated lime, insectary experiments.

Similar results were obtained from small field plots sprayed thoroughly with a hand sprayer. Bordeaux was more effective in preventing flea beetle and leafhopper injury as indicated in table 1. Only one concentration, 8–50 hydrated lime and 4-8-50 bordeaux, was used in this field test.

The significant difference in repellency between the bordeaux and hydrated lime may be due also to the presence of the copper component in the former. The influence of the copper may be shown in another insectary experiment in which the various combinations of three levels of each component of bordeaux were compared for

repellency. The three amounts of copper sulphate and hydrated lime were based on dilutions of 2, 4, and 8 pounds to 50 gallons of spray. Thus, the various formulae compared for repellency were 2-2-50, 2-4-50, 2-8-50; 4-2-50, 4-4-50, etc. The summary of flea beetle injury is presented in table 2 and graphically illustrated in figure 2. In table 2 the data are grouped into three classes representing a single level of one component with three levels of the other. Thus, note in the upper portion of the table that for each dilution of copper sulphate the hydrated lime was varied,

Table 2.—Comparison of the repellency of various bordeaux formulae using combinations involving three levels of each component, insectary experiments.

Bordeaux Formula		Average Number of Flea Beetle Feeding Holes per Plant
Copper Sulphate	Hydrated Lime	
2	2	777.5
2	4	263.5
2	8	179.0
4	2	520.5
4	4	224.5
4	8	82.0
8	2	198.2
8	4	164.0
8	8	136.0
2	2	777.5
4	2	520.5
8	2	198.2
2	4	263.5
4	4	224.0
8	4	164.0
2	8	179.0
4	8	82.0
8	8	136.0

Significant differences:
Between formulae significant at 1% level
Between levels of lime significant at 1% level
Between levels of copper significant at 1% level
Interaction copper×lime significant at 1% level

whereas in the lower portion the data are regrouped so that for each level of hydrated lime the copper sulphate was varied.

An examination of the data indicates that increments of either hydrated lime or copper sulphate progressively increased the repellent effect of the spray. The most pronounced variation occurred between increments of one component when the other was used at the lowest level. A high concentration of either copper sulphate or hydrated lime within the limits used gave good repellency. Increasing the concentration of one component when the other was at a high level did not materially improve the spray in this test.

FIELD EXPERIMENTS.—Field experiments have been conducted over a three-year period. In 1940 four formulae were compared starting at a low level of hydrated lime as a 4-1-50 and successively doubling the amount of lime to a level of 8 pounds. Seven applications were made during the season.

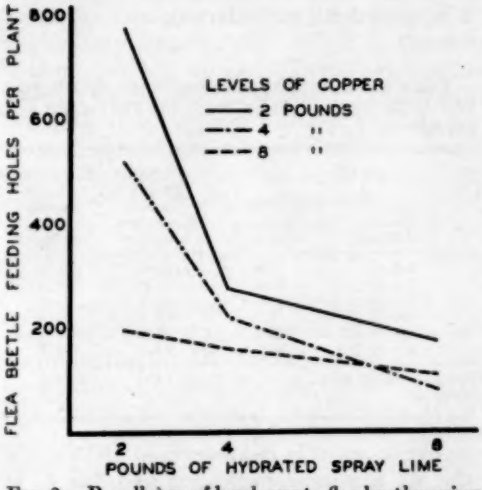

FIG. 2.—Repellency of bordeaux to flea beetles using combinations involving three levels of copper sulphate and hydrated lime, insectary experiments.

Flea beetles were severe in this experiment and caused considerable damage, particularly during a drought period of midsummer. Leafhoppers were also abundant but their injury was not as noticeable as that of the flea beetles. A few tarnished plant bugs were present but probably caused little damage. Aphids were too few in number to present a problem.

Table 3.—Summary of tuber yields, flea beetle and leafhopper populations and injuries from the 1940 field experiment.

Bordeaux Formulae	Yields in Bushels per Acre	Flea Beetles in 20 Net Sweeps	Flea Beetle Feeding Holes per Leaflet	Leafhoppers in 20 Net Sweeps
4-1-50	290.1	376.3	163.8	77.5
4-2-50	280.9	436.3	165.0	90.0
4-4-50	319.4	261.3	111.3	57.5
4-8-50	330.2	238.8	71.3	46.3
Least difference for significance 5%	31.8	44.5	40.2	none

The data on sampling for flea beetle and leafhopper populations, flea beetle injury and tuber yields have been tabulated in table 3. The populations of these pests and their damage was in general decreased by progressively increasing the lime from one pound to eight pounds per fifty gallons of bordeaux mixture. The estimates of tuber yields also progressively increased in the same manner. Curiously, the neutral bordeaux 4-1-50 is slightly superior in both insect control and yields, but this is of doubtful significance. The neutral formula was discontinued from further tests since it is used with considerable risk of plant injury.

Table 4.—Summary of tuber yields, flea beetle and leafhopper injuries from the 1941 field experiments.

Bordeaux Formulae	Yields in Bushels per Acre	Flea Beetle Feeding Holes per Leaflet	Per Cent of Leafhopper Injured Leaflets
4-2-50	189.3	110.8	60.0
4-4-50	242.3	78.5	41.4
4-6-50	248.4	69.2	32.8
4-8-50	261.9	50.0	20.4
6-4-50	226.7	55.9	30.2
8-4-50	240.8	60.5	32.0
Least significant 5% difference 1%	40.3	20.0 27.7	9.6 13.3

The work was continued in 1941 using the six formulae indicated in table 4. It will be noticed that two formulas were used which contained increased amounts of copper sulphate. This made possible a comparison of two series; one in which the lime is increased and the copper sulphate is constant; the other in which the copper sulphate is varied and the lime remains constant.

Seven applications were applied during the growing season. Flea beetles were again very destructive and leafhoppers were more abundant than the year previous. The potato aphid, *Macrosiphium solanifolii*, appeared late in the season but it was not serious as cool, rainy weather checked the infestation. Late blight was not present in the plots at any time during the season.

In table 4 the data for insect injury and tuber yields have been summarized. As in the previous experiment an increase in the amount of hydrated lime from 2 to 8 pounds progressively increased the repellency of the bordeaux when the copper sulphate content was used at a level of 4 pounds. It will be noted that an increase in the copper sulphate content of the bordeaux from 4 to 6 pounds slightly increased the repellency of the spray. A further increase of the copper content to 8 pounds did not improve the repellent effect of the mixture.

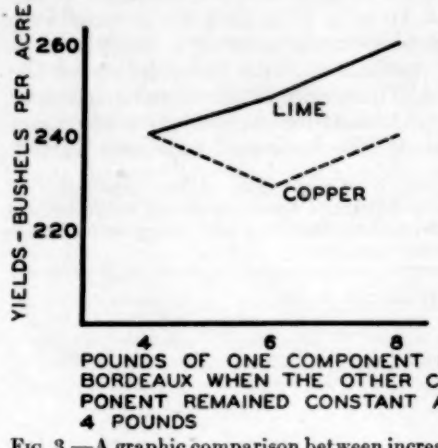

FIG. 3.—A graphic comparison between increasing the lime content and the copper sulphate content of bordeaux on tuber yields, 1941 field experiment.

The estimates of the tuber yields indicated a response to increasing the amount of lime when the copper sulphate content was 4 pounds, particularly from the 2 to the 4-pound level of lime. On the other hand an increase in the copper sulphate concentration from 4 to 8 pounds did not increase the yield. The relationship of the two series when in one case the lime and in the other case the copper sulphate was varied, is shown in figure 3. From the standpoints of both repellency and yields an increase in the copper sulphate content over 4 pounds was unnecessary.

In the field experiment conducted dur-

Table 5.—Summary of tuber yields, flea beetle and leafhopper injuries from the 1942 field experiment.

Bordeaux Formulae	Yields in Bushels per Acre	Flea Beetle Feeding Holes per Leaflet	Per Cent of Leafhopper Injured Leaflets
4-2-50	263.9	40.3	54.2
4-4-50	302.1	33.1	43.6
4-6-50	307.6	24.1	29.2
4-8-50	311.4	23.5	29.0
6-2-50	285.6	39.3	47.8
6-4-50	311.9	27.1	33.6
6-6-50	306.2	19.5	31.6
6-8-50	313.9	21.0	28.6
Least significant 5% difference 1%	33.6	9.6 7.1	15.5 11.4

ing the 1942 season[1] two dilutions of copper sulphate, 4 and 6 pounds, were used with the four levels of lime. This constituted a factorial type of experiment. Late blight was epidemic for the first time in the 3-year period that this work has been conducted. The sprayed plots were well protected although some blight occurred throughout the field. As far as could be determined 4 pounds of copper sulphate to 50 gallons of bordeaux was as effective against the blight as the higher 6-pound level. Flea beetles and leafhoppers were again numerous and their injuries were evident throughout the season. An early frost in late September killed the potato plants while the foliage was still very green.

The insect injury and yield data tabulated in table 5 again shows that increasing the lime content of the bordeaux progressively increased the repellent value of the bordeaux and increased yields. There was an advantage in using the higher copper sulphate content at the low level, 2 pounds, of lime. However, 6 pounds of copper sulphate with four or more pounds of lime were not materially better than 4 pounds of copper sulphate with these same levels of lime. As was noted in the previous experiment, the greatest response from the standpoint of yields was between the 2- and 4-pound level of lime when the copper sulphate content was constant at 4 pounds.

DISCUSSION.—When bordeaux is used to protect potatoes against pests, it is essentially a repellent to flea beetles and leafhoppers. The two components of the mixture may be varied according to the problem at hand. In practice potato growers ordinarily use 4 to 5 pounds of copper sulphate to 50 gallons of bordeaux. In the experiments herein reported, higher levels of copper sulphate did not seem necessary if sufficient hydrated lime was used properly to repel flea beetles and leafhoppers.

The amount of hydrated lime in the bordeaux necessary for the best control of flea beetles and leafhoppers under the conditions of the experiments depended upon the dilution of copper sulphate used. In insectary tests progressive increases of lime markedly improved the repellency of the spray when combined with a low concentration, 2–50, of copper sulphate. The same was true of successive increments of copper sulphate when used with a low content of lime. On the other hand the increase of one component when combined with a high concentration of the other only slightly improved the protective value of the bordeaux.

Similar results were obtained from the field experiments. Successive 2-pound increments of hydrated lime from 2 to 8 pounds when used with 4 pounds of copper sulphate progressively increased the protection from flea beetles and leafhoppers. When increased concentrations up to 8 pounds of copper sulphate were tried a slight improvement was noted in the repellency of the spray although the data are not consistent. In general, the results indicate that within the concentrations compared in the field experiments, a bordeaux formula consisting of more copper sulphate than hydrated lime was no more effective in preventing insect damage than a formula with a lime content higher than that of copper sulphate.

Tuber yields from the field experimental plots have been consistent for the three years indicating the benefits derived from increasing the lime content of the spray. When the minimum amount of copper sulphate, 4–50, was used increments of lime from 2 to 8 pounds progressively increased yields. At a level of 4 pounds of lime an increase in the copper sulphate content in bordeaux within the limits tried did not prove to be necessary.

The yield data from the three formulae, 4-2-50, 4-4-50, 4-8-50, common to all the field experiments have been analyzed together and presented in table 6. It is apparent that the most pronounced increase in yield from increasing the lime content of the bordeaux occurred between the 2 and 4 pound levels. A regression analysis of lime on yields showed that the data in each case fitted a straight line. This would indicate that even greater increases in yields might be expected with further improvement in the protection afforded by bordeaux mixture. However, the data show that the advantage of using more than 4 pounds of hydrated lime is small and of questionable significance. The estimates of flea beetle and leafhopper damage indicate that the most effective formula, 4-8-50, did not entirely prevent injury. Whether or not better control

[1] Mr. R. O. Erickson, Assistant in the Department of Agricultural Engineering, supervised the spraying of the plots. Mr. Edgar Curtis assisted in making the insect counts.

Table 6.—Summary of tuber yields from plots sprayed with 4-2-50, 4-4-50, and 4-8-50 bordeaux mixtures, 1940-42 experiments.

	4-2-50	4-4-50	4-8-50
Experiment 1	280.9	319.4	330.2
Experiment 2	189.3	242.3	261.9
Experiment 3	263.9	302.1	311.4
Average	244.7	287.9	301.2
Least difference for significance 5%		27.1 bushels	
1%		37.1 bushels	

than that provided by this formula would be reflected in yields is not known.

The results of these field experiments did not confirm the data obtained by Mader & Blodgett (1935) and do not support their conclusions. It is probable that factors other than insect control may influence the effects of sprays and dusts on potato yields. The results reported do not disprove the possibility of copper stimulation, or stunting as reported by Boyd (1926). In the absence of heavy flea beetle and leafhopper infestations the physiological effects of the spray on the potato plants might outweigh insect injury whereas heavy insect infestations might have more influence on yields than stimulation or injury due to the spray. In the latter case better control would more than counteract the adverse physiological effects, if any, from a high lime bordeaux. Enlightment on this question must await further investigations.

CONCLUSIONS.—Bordeaux mixture is the standard fungicide and insecticide used for the control of pests on potatoes grown in New York. A low lime formula commonly recommended has not been entirely satisfactory in regions where flea beetles and leafhoppers are important pests. Insectary and field experiments have been conducted to determine a more efficient formula for insect control.

From insectary tests it was found that hydrated lime was not as repellent to flea beetles as bordeaux. However, successive increments of lime from two to eight pounds in 50 gallons of bordeaux progressively increased the repellency of the mixture. The increase in effectiveness was most pronounced at a low level, 2–50, of copper sulphate. At the highest concentration of copper sulphate used, 8–50, the low lime spray was only slightly inferior to the spray containing a maximum level of hydrated lime. Considering the various dilutions of copper sulphate, similar trends were noted when the amounts of copper were varied within the limits of 2 to 8 pounds per 50 gallons of bordeaux.

Data from field experiments further indicated that the protection against flea beetles and leafhoppers afforded by bordeaux was better with a high lime formula than with a low lime formula. Tuber yields were likewise increased with successive increments of lime. However, the most pronounced increase occurred between the 2- and 4-pound levels of lime. A concentration of copper sulphate greater than 4 pounds did not seem necessary during the years these experiments were conducted.

These results did not confirm previous work in other sections of the state were it was found that a low lime formula was superior to a high lime bordeaux. The extent of copper stimulation or bordeaux injury could not be determined from these experiments.—S-2-44.

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DR. J. A. HYSLOP RETIRES

Dr. James A. Hyslop has availed himself of his privilege of retirement after 38 years of service in the Bureau. He has been connected with the survey since 1920. The entomological friends of Dr. Hyslop may be sure that, while he is retiring from the Bureau he is not by any means retiring from entomology and that he still has important contributions to make to the science.

Tests of DDT for the Control of Potato Insects[1]

A. A. Granovsky, *Division of Entomology and Economic Zoology, University of Minnesota, St. Paul, Minn.*

Minnesota is one of the leading states in the production of potatoes, for consumption, as well as for seed purposes. During the last several years Minnesota has steadily occupied either third or fourth place in the production of potatoes in the country, and second or third place in the production of seed potatoes. With the assigned quota of 256,000 acres of potatoes for the state in 1943, special efforts were made to improve the control of the common potato insects, through a series of factorial experiments conducted by the Minnesota Experiment Station since 1940.

In the past season of 1943, not less than 25 distinct dust and spray experimental combinations of various insecticides and fungicides were used in several potato growing areas of the state. In addition to the tests of various modifications of the ingredients and combinations of the more common insecticides and fungicides, several new insecticides and materials were tried that might offer some insecticidal value or improvement in the efficiency of potato dusts or would reduce the content of the allocated insecticides for the duration. Among the new materials it was possible to include dichloro-diphenyl-trichloroethane in some of the field experiments, when preliminary trials indicated that it was safe to use it on potato foliage.

Experimental Procedure.—Field experiments to determine the effectiveness of DDT, abbreviation for dichloro-diphenyl-trichloroethane, in the control of potato insects were made only in three out of seven commercial potato fields used in the season of 1943 in connection and in comparison with other insecticides tried in factorial experimentation. These experiments were designed on a fairly large scale and the inclusion of DDT was made on a theoretical assumption for the control of potato leafhoppers mainly.

The selection of suitable potato fields was determined by (1) the habitual high population of either potato leafhoppers or fleabeetles in the two main potato growing regions of the state, (2) the uniformity of the potato stand over the entire field, (3) the size and shape of each field for sufficient replication of randomized plots, and (4) the uniformity of type of soil and topography of the ground so necessary for comparable results.

One of such commercial fields was located in the central part of the state near Princeton, Minnesota on peat land, planted to the Red Warba variety of potatoes. It was divided into 36 plots, six rows each, running somewhat less than a quarter of a mile and having rows 3 feet apart. The area of each plot measured 0.383 acre. Three replications were made of 12 different dusts in randomized distribution of the plots, thus giving 1.15 acres for each treatment. This field was dusted five times from July 20 to August 27, 1943, at the rate of approximately 25 and 30 lbs. per acre. DDT was applied as a dust at 5 per cent level in *Pyrax ABB*, by a *John Bean* 6-row power take-off duster at about 6 miles per hour. The dust at this level, as well as those at other concentrations used in these experiments, was prepared from pure amorphous dry chemical and supplied for the experimental purpose by McConnon & Co. of Winona, Minnesota.[2]

Another field was located in the eastern section of the state near Harris, Minnesota on peat land, planted to the Irish Cobbler variety. This field consisted of six plots of 20 rows each, planted 3 feet apart and a quarter of a mile long. The area of each plot measured 2.12 acres. The DDT, 5 per cent dust, was used at the rate of 30 lbs. per acre on one of the plots at the third dusting, August 6, 1943, aiming mainly against leafhoppers, which as a rule reach a high population at this time of the season. The dust was applied by the *Niagara* 4-row traction duster. Two previous dusting consisted of combinations of *Yellow Cuprocide*, pyrethrum and rotenone.

The third field was selected near East Grand Forks, in the Red River Valley which is the most extensive potato grow-

[1] Paper No. 2152 Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul.

[2] Grateful acknowledgement is being made at this time to McConnon & Co. of Winona for its splendid continued cooperation in these experiments.

ing section in the northwestern part of the state. This field of Irish Cobblers planted on rich clay loam soil typical of the Red River Valley, was divided into 12 plots. Each plot consisted of four rows, 3 feet apart and a quarter of a mile long. The area of each plot measured 0.424 acre. Four distinct treatments were used in three randomized replications, thus each treatment comprised an area of 1.27 acres. Two DDT dusts were applied by the *Niagara* 4-row duster of traction type at 1 per cent and 2.5 per cent concentrations, using 25 lbs. per acre. Only one specially planned application on August 23, 1943 was made in this field, which was heavily infested with both fleabeetles and leafhoppers. It also was moderately infested with the tarnished plant bug and other insects.

The application of all dusts was made in the evening, after the wind had subsided, and usually in the presence of some dew. All applications were made by field machinery, operated by skilled regular farm personnel, acquainted with the operation of the dusting and traction machinery. Each application was made under close supervision of the Division of Entomology and Economic Zoology of the University of Minnesota, at which time a careful record was taken of weather conditions, temperature, wind velocity and direction, condition of the plants, their height, the qualitative and quantitative insect infestation, rate of application, the direction and the extent of dust drifting, presence and abundance of dew, flocculency and feeding behavior of each dust and other pertinent data.

In order to determine the efficiency and the duration of effectiveness of each insecticide, a periodic insect survey was made at regular intervals in each plot of each replication. An accurate determination of the leafhopper and fleabeetle population was made (1) before each dusting, (2) usually within 24 hours after each dusting, and (3) at any other period specified in the treatment of the results. A careful record of ecological conditions was taken in connection with each count.

These periodic counts of the insects in question were made by uniform sweeps with an insect net over the undisturbed plants at random in the two center rows of each plot, beginning about 25 or 30 feet in from the margin and working toward the middle of the field. Five double sweeps constituted a single sample. Five of such samples were taken, giving 50 sweeps per each plot, and 150 of such sweeps for three replications of each insecticide. Early in the season when the insects were few, they were counted in the net right in the field after each set of five sweeps. Later, when the insect population increased, they were first cyanided in specially prepared and labeled bottles for each plot, and accurate counts were made in the laboratory. The results of these sweeps were recorded on forms specially prepared for the purpose and for further treatment.

All fields were infested with much the same species of common potato insects, although with different densities of given species. Potato fleabeetles, *Epitrix cucumeris* Harris, were extremely abundant in the Red River Valley, while the potatoes in the central and eastern sections of the state were only moderately infested with fleabeetles. On the other hand, potato leafhoppers, *Empoasca fabae* (Harris), and *Macrosteles divisus* (Uhler), were more abundant in the latter sections than in the Red River Valley. Such insects as the tarnished plant bug, *Lygus oblineatus* (Say), the Colorado potato beetle *Leptinotarsa decemlineata* (Say), the alfalfa plant bug, *Adelphocoris lineolatus* (Goeze), and to a lesser degree the rapid plant bug, *Adelphocoris rapidus* (Say), were found in considerable numbers in all fields. The numerical data have been kept and biometrically treated only for fleabeetles, leafhoppers and tarnished plant bugs. Only general observations were made on the action of DDT on the other insects listed above.

Though DDT was used in comparison with other insecticides in these experiments, only the results for DDT are given here, together with the check, with the exception of the special trial in the Red River Valley, where the results of the entire experiment are included.

EFFECT OF DDT POTATO INSECTS.—From the description of the experimental procedure it will be seen that DDT was used as a dust at 1, 2.5 and 5 per cent concentrations with several replications in large field tests on the commercially grown potatoes of two varieties. In the Princeton area DDT at a 5 per cent level dust was applied on the following dates:

1st application—July 20, 1943, at 5:00

Table 1.—The effect of DDT on the potato fleabeetle population at Princeton, Minn. during the entire growing season of 1943.

	MEAN POPULATION OF FLEABEETLES AT GIVEN PERIODS AFTER								
	First Dusting		Second Dusting		Third Dusting		Fourth Dusting		Fifth Dusting
TREATMENT	1 day	12 days	1 day	10 days	1 day	7 days	1 day	8 days	1 day
Check	—	39.0	20.3	159.0	99.3	61.7	41.6	52.3	19.3
DDT—5%	—	19.0**	0.0**	71.7**	1.6**	16.3**	0.0**	13.6**	0.0**
*S.D. (.05%)	—	11.82	1.80	34.99	20.91	25.97	8.19	12.87	2.68
**H.S.D. (.01%)	—	16.06	2.45	47.56	28.42	35.29	11.13	17.50	3.64

P.M. with a temperature of 27.8° C., no dew, and a wind velocity of about 5 miles per hour and a slight northwest drift.

2nd application—Aug. 2, at 8:00 P.M. at 21.0° C., very slight dew and perfectly still weather without drift.

3rd application—Aug. 12, at 9:00 P.M. at 24.0° C., considerable dew and slight wind about 2 miles per hour and a very slight westward drift.

4th application—Aug. 19, at 7:30 P.M. at 22.8° C., slightly forming dew, quite still with hardly any drift to northwesterly direction.

5th application—Aug. 27, at 9:00 P.M. at 14.4° C., some dew, very still without much drift.

The insect population was determined on all plots in the afternoon before each dusting and again by early afternoon the next day, recording the existent ecological conditions during the process of sweeping. The count before each succeeding application constituted at the same time the last count after each preceding dusting, thus giving additional information on the duration of the effectiveness of each previous application.

The results of the effectiveness of DDT of the potato fleabeetles are presented in table 1, and on the leafhoppers in table 2.

In analyzing the data presented in this table it will be observed that there were no fleabeetles present in the pertinent plots one day after the first dusting. In fact, very few fleabeetles were recorded at that time in the entire field before the first dusting. This probably was due to the fact that the peat land is heavily saturated with snow water and low peat land is often submerged for weeks before planting thus rendering it an unsuitable abode for the overwintering of the adult fleabeetles. Only by the first of August of that year did they appear in any numbers in the potato fields planted on peat land in the vicinity of Princeton.

The statistical treatment of the data strongly points to the highly significant results. The analysis of variance for treatment differences shows that the probability exceeds 0.01 per cent point in all insect counts after all applications of DDT. It is of interest to note that not only in the counts one day after each application do we have highly significant differences as compared with the undusted plots, but that the same level of significance is main-

Table 2.—The effect of DDT on the potato leafhopper population at Princeton, Minn. during the entire growing season of 1943.

	MEAN POPULATION OF LEAFHOPPERS AT GIVEN PERIODS AFTER								
	First Dusting		Second Dusting		Third Dusting		Fourth Dusting		Fifth Dusting
TREATMENT	1 day	12 days	1 day	10 days	1 day	7 days	1 day	8 days	1 day
Check	33.0	36.7	30.7	81.0	89.3	107.0	115.7	117.0	100.7
DDT—5%	4.3**	17.0**	3.0**	29.3**	3.7**	23.3**	3.7**	35.7**	2.0**
*S.D. (0.05%)	7.61	9.58	8.45	12.51	14.47	14.25	23.48	25.59	10.26
**H.S.D. (0.01%)	10.34	13.02	11.48	17.01	19.66	19.36	31.92	34.78	13.94

tained for nearly two weeks after dusting until the next application throughout the season. The frequency of dusting toward the end of the season was determined by the need of fungicidal applications to prevent late blight epiphytotics, at which time DDT was applied to the designated plots but without a fungicide.

The effect of DDT on leafhoppers according to the analysis of variance of treatment is also highly significant for all leafhopper counts. It gave a remarkable control of leafhoppers within about 12 hours and its residual efficiency evidently lasts for not less than two weeks. In all probability it lasts for a much longer period. Considering the progressively greater differences in the insect populations between the treated and untreated plots for both the leafhoppers and fleabeetles with each repeated application, one may assume that there is a cumulative residual value of this insecticide.

Similar results were obtained in the Red River area near East Grand Forks, where the application of DDT was specially designed to test it at 2.5 and 1 per cent levels, using only 25 lbs. of dust per acre in the field very heavily infested with fleabeetles and a considerable number of leafhoppers and other potato insects. Only one application was made on August 23, 1943 at 6:00 P.M. with the temperature at 31.6° C. and no dew. There was a slight breeze from the northeast and the dusts drifted across the other plots in a southwesterly direction.

The results are presented in the following tables:

Table 3.—The effect of DDT on the potato fleabeetle population at East Grand Forks, Minnesota after dusting August 23, 1943.

	Mean Population of Fleabeetles at Given Periods			
		Significant Differences After Dusting		
Treatment	Before Dusting	2 days	4 days	6 days
Check	413.6	227.0	233.0	352.0
M-O-B	—	81.0**	93.0*	143.7**
DDT-2.5%	—	4.0**	7.3**	44.0**
DDT-1%	—	18.3**	32.3**	70.0**
*S.D. (0.05%)	—	82.80	129.73	80.06
**H.S.D. (0.01%)	—	125.38	196.46	121.23

In addition to the two DDT dusts and check plots, a dust recorded here as *M-O-B* was used, which consisted of 14 per cent of tribasic copper sulphate, 20 per cent calcium arsenate and 10 per cent rye flour, with metallic copper content at a 7 per cent level. This dust was prepared by being ground in a commercial ball mill and supplied by McConnon & Co. of Winona. All dusts were applied in three replications. The insect population was determined by sweeping and cyaniding three times at two-day intervals after dusting as indicated in the tables.

The statistical analysis of the fleabeetle counts for all three periods after dusting very definitely shows the high significant differences in results for both concentrations of DDT dusts, with somewhat higher mortality in favor of the 2.5 per cent dust for all counts. A rather striking reduction of the potato fleabeetle population is noticed, perhaps more spectacular than is obtained by any other insecticide used in the control of these insects in all the extensive experiments conducted by this Station in the last five years. On account of the considerable dust drift there is a considerable reduction of fleabeetles in the check plot over the initial infestation. *M-O-B* dust stands in the intermediate position. Its plots also received some benefit from the DDT dusts drift.

Table 4.—The effect of DDT on the potato leafhopper population at East Grand Forks, Minn. After dusting August 23, 1943.

	Mean Population of Leafhoppers at Given Periods			
		Significant Differences After Dusting		
Treatment	Before Dusting	2 days	4 days	6 days
Check	51.6	37.0	41.7	47.3
M-O-B	—	26.7*	32.0	47.7
DDT-2.5%	—	10.0**	13.7	40.0
DDT-1%	—	10.3**	20.7	46.0
*S.D. (0.05%)	—	8.94	Treatment differences are not significant	Treatment differences are not significant
**H.S.D. (0.01%)	—	13.53		

The results obtained in the control of the potato leafhoppers according to the analysis of variance for treatments are not as striking as those obtained for fleabeetles. Nevertheless the reduction of the leafhopper population for the first 2-day period is highly significant for both concentrations of DDT dusts. The leafhopper counts at 4- and 6-day periods after dusting did not show statistically significant differences. The agility of the leafhoppers and their migratory habits may in part account for this phenomenon, especially

in the northern part of the state, where leafhoppers appear in numbers only toward the latter part of the season.

It is of interest to compare the percentages of reduction of the more common potato insects over the check plot at given intervals after the dusting with DDT, as well as over the initial infestation recorded before dusting. Such summaries are given in tables 5 and 6, as well as in figure 1.

In analyzing tables 5 and 6, as well as figure 1, it will be observed at a glance that the greatest reduction in insect populations due to DDT dusting is recorded for fleabeetles. It is apparent that fleabeetles are controlled by this insecticide to a high degree, and that their reduction is maintained for at least one week on a high level. On the other hand, the reduction in the leafhopper population is not as great, and neither is it as enduring. By the end of six days, the percentage of leafhopper reduction in dusted plots over the check plots is rather insignificant. It may be taken as an indication that the duration of the effect of DDT on leafhoppers is rather limited and is of different order than that on the fleabeetles, suggesting the highly selective action of this insecticide on different species of insects. Such reasoning is supported by the entirely opposite results obtained in the effect of DDT on the tarnished plant bug. It will be observed that the percentage of reduction of this insect, with the exception of the second count for the 1 per cent dust, has gradually increased and at the end of the 6-day period the control of this insect was considerably greater than at the earlier periods after dusting. This definitely indicates either one or two possibilities. It is quite possible that it takes a longer time to kill a somewhat larger insect by the contact dust, coming in contact with the insect at the time of dusting. It is also possible that there is a residual contact value in this insecticide deposited on the potato foliage, with which the susceptible insect comes in contact during its feeding some time after dusting.

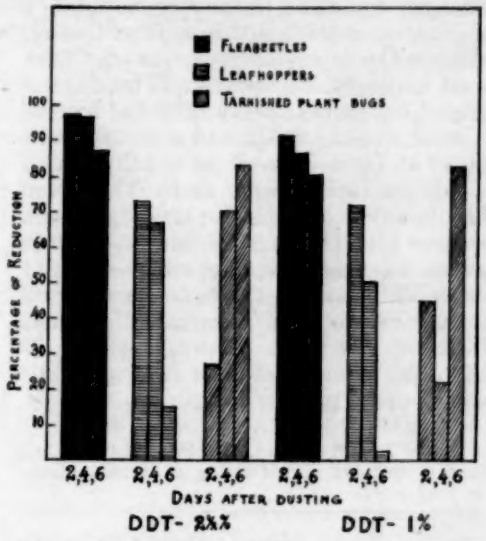

FIG. 1.—The effect of 2.5 and 1 per cent of DDT dusts on the common potato insects in percentages of reduction over the check plot of 2, 4 and 6 day intervals after dusting, East Grand Forks, Minn., 1943.

In the Harris area, the DDT dust at the 5 per cent concentration at the rate of 30 lbs. per acre was used only at the third

Table 5.—The effect of DDT on three common potato insects in percentages of reduction over the check plot at given periods of time after dusting at East Grand Forks, Minn. 1943.

	FLEABEETLE			LEAFHOPPER			TARNISHED PLANT BUG		
TREATMENT	2 days	4 days	6 days	2 days	4 days	6 days	2 days	4 days	6 days
DDT—2.5%	97.3	97.1	87.6	73.0	67.2	15.5	27.2	70.4	83.4
DDT—1%	91.9	86.2	80.4	72.0	50.4	2.8	45.0	22.2	83.4

Table 6.—The effect of DDT on three common potato insects in percentages of reduction at given periods of time after dusting over the initial infestation at East Grand Forks, Minn., 1943.

	FLEABEETLE			LEAFHOPPER			TARNISHED PLANT BUG		
TREATMENT	2 days	4 days	6 days	2 days	4 days	6 days	2 days	4 days	6 days
DDT—2.5%	98.7	97.9	89.1	80.6	73.5	22.6	66.6	77.2	85.8
DDT—1%	95.4	92.1	83.1	80.0	60.0	10.9	68.6	40.0	85.8

dusting, when the leafhopper population reached a menacing threat. The fleabeetles, on the other hand, in this peat field, were in negligible numbers. This field of Irish Cobbler potatoes was dusted August 6, 1943, at 8:55 P.M., at the temperature of 22.4° C. with a slight southwesterly wind, producing some drift. There was hardly any dew. This was the largest area treated with DDT, comprising 2.12 acres, which was dusted in comparison with five other similar areas treated with different dust combinations. The results given in table 7 are only those pertaining to the 5 per cent DDT dust in comparison with a check plot.

Table 7.—The effect of DDT on the potato insects one day after dusting at Harris, Minn., in 1943.

Dust	Mean Population of Insects One Day after Dusting	
	Leafhoppers	Fleabeetles
Check	58	7
DDT—5%	17.6**	0
*S.D. (0.05%)	13.84	Treatment differences are not significant
**H.S.D. (0.01%)	19.67	

Unfortunately, on account of a shortage of assistance, it was impossible to make additional periodic surveys of insect populations. The one day count, however, gave highly significant differences for leafhopper control, although not as striking as for the fleabeetles in other areas. The analysis of variance shows no significant differences between the treatments for fleabeetles in this field, mainly because of the very low initial fleabeetle population, for the reasons explained before.

In addition to the above numerical data, presented mainly for *Empoasca fabae*, *Epitrix cucumeris* and *Lygus oblineatus*, it is of interest to record some general field observations on the action of DDT on other potato insects found in smaller numbers in all fields in the course of these experiments. It was observed that other species of leafhoppers, especially that of *Macrosteles divisus*, behave in regard to DDT much in the same way as *Empoasca fabae*. The alfalfa plant bug, *Adelphocoris lineolatus*, which is very common in the potato fields in Minnesota and the less common *A. rapidus* respond to this insecticide in the same pattern as does the tarnished plant bug, *Lygus oblineatus*. On account of the very low aphid infestation in most of the fields, no efforts were made to record their reaction to DDT at this time. Sufficient observations were made to note that *Leptinotarsa decemlineata* to all appearances is quite effectively controlled especially in larval stages.

This account would not be complete without stating that at the Harris area two of the men suddenly developed rather severe respiratory disturbances, presumably on account of an irritation by some of the dusts used. By process of elimination the DDT dust was at first suspected of causing the respiratory trouble. It was, however, used on several previous occasions without complications, By further retracing of all activities of the affected men, it became evident that DDT was not responsible for the trouble. It must be kept in mind that all insecticidal and fungicidal dusts used in the potato fields are toxic under careless handling.

THE PLACE OF DDT AS AN INSECTICIDE FOR POTATO INSECTS.—While these field experiments, though performed on a large scale, must be considered as of a preliminary nature, nevertheless, they definitely indicate that DDT may become one of the most important insecticides in the control of both mandibulate and haustellate insects in potato fields. It is apparent that at as low a concentration as 1 per cent in a dust diluted in Pyrax ABB, it gave a rather striking control of fleabeetles, which are difficult insects to control under any circumstances. It is very promising in the control of the Colorado potato beetle, the tarnished plant bug and other Mirids. Though it is apparently less effective against leafhoppers, yet it gives results comparable with other insecticides used in the control of these insects.

In view of the extreme shortage of pyrethrum and rotenone for agricultural purposes at present, and because dichlorodiphenyl-trichloroethane can be synthesized commercially in this country at a relatively low price, it may become one of the promising substitutes for well established insecticides. It appears that if several insects of diverse feeding habits can be controlled by one insecticide, thus diminishing the need for several applica-

tions of different insecticides to control the same, the reduction in the cost of operation alone is a considerable item.

In addition to the insecticidal value it has been observed that DDT has a considerable fungicidal value as late blight of potatoes was not so prevalent in plots dusted with a 5 per cent material as in plots treated with some fungicides commonly used in potato fields.

On the basis of one year of field experience it is evident that it can be safely used on potatoes for it lacks of phytocidal action. Moreover, the deposit on potato foliage or foliage of other crops, which is not used for food, is not as dangerous as it might be if DDT were used on leafy vegetables, fruits and other food substances usually consumed by man or domestic animals. It is quite possible that the residues of DDT left on the foliage of plants, when used for human consumption, may be absorbed from the digestive tract and produce deleterious effects. The entire question of its possible use on fruit and leafy vegetables requires not only reasonable precautions, but further extensive studies even though it should prove that its toxicity to man and warm blooded animals is of a lower order than most of the insecticides now commonly used. More information is needed on its toxicity and health hazards involved in the residues on plant foliage.—3-14-44.

Populations of the European Red Mite as Affected by Spray Schedules

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The introduction of any new or modified material into the spray schedule for the control of a specific pest or disease is apt to produce significant changes in the status of other control problems. For example, the use of nicotine in schedules against the codling moth has, in several orchards, produced a problem in the control of the apple maggot. Phenothiazine in continuous applications on apple has permitted increases in the population of the European red mite. The use of a dormant oil spray against the red mite usually results in adequate control for the current season, but, if omitted the next spring, tremendous mite injury almost invariably develops during the succeeding summer.

Since the European red mite problem is quite serious in northeastern Ohio and since many unusual fluctuations in the populations of this pest had been observed, a 5-year experimental program to investigate certain of these phenomena was started by the Ohio Station in 1939. This program was designed to follow or keep track of the mite populations throughout each season on plots sprayed with representative Ohio schedules. In addition, certain schedules specially designed for mite control were to be studied.

TECHNIQUE.—Single-tree plots replicated from three to five times for each variety have been used. At least two apple varieties have always been included in the tests, usually Red Rome and Cortland. King David and Stayman have also been used in certain seasons.

When the project was started in 1939, it was hoped that population counts could be made every 10 days or 2 weeks. At the outset, counts were made of mites and eggs on 25 leaves from each replicate, but it was found impractical to continue this procedure, due to the labor involved. After the first season, counts were made about every 3 weeks and the number of leaves from each replicate was reduced—first, to 20 in 1940 and 1941 and, then, to 10 in 1942 and 1943. Ten leaves have proved to be an adequate sample. The counts of mites and eggs on each leaf were made under the binocular microscope. The 10 leaves were taken at random around the tree's periphery. They were dropped into a paper sack, taken to the field counting station, and examined at once.

SPRAY SCHEDULES EMPLOYED AND RESULTS.—From 1935 to 1939 flotation sulfur paste replaced lime-sulfur as a fungicide in many northern Ohio orchards. During this period many people complained that red mite was more abundant, and frequently they blamed flotation sulfur for the increase. In order to determine

the truth of this matter, comparable plots were sprayed with flotation sulfur and with liquid lime-sulfur. This series was started in 1939 and concluded in 1942.

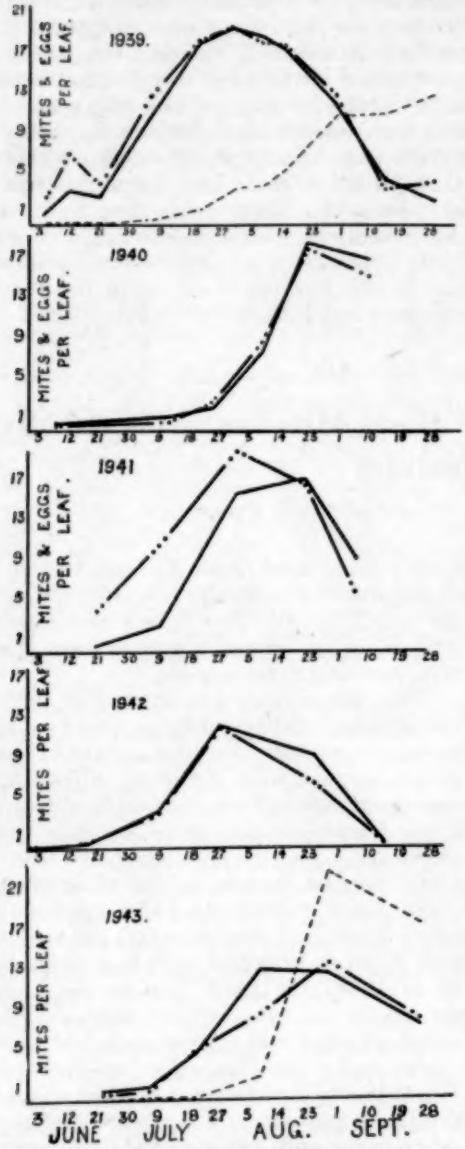

FIG. 1.—Seasonal populations of European red mite as affected by different spray schedules. Solid line: Flotation-sulfur paste throughout growing season. Dot-dash line: Liquid lime-sulfur throughout growing season, except in 1943 when *sulforon* was used. Dash line: (1939 and 1943 only) flotation-sulfur schedule preceded by dormant oil.

The results for the 4 years are shown in figure 1, 1939–1942. In 1943 (Fig. 1) a variation in the program is explained in the following text.

In 1939 no dormant oil or other early-season aracnicide was usedon either plot. In early June there was a heavier mite population on the liquid lime-sulfur plot, but this gap was soon closed and the populations were almost identical for the remainder of the season. The graph shows that high populations existed in late July and early August, followed by a rapid decline in numbers toward the end of the season. The dash line represents the population on a flotation-sulfur-sprayed plot on which a dormant oil had been applied. The low population of mites during early and mid-season, with rapidly increasing numbers in late August and September, is characteristic of this type of schedule. In 1940 both plots received dormant oil. The mite populations were almost identical throughout the entire season and the curves followed closely the pattern that is characteristic of any schedule which includes dormant oil. In 1941 there was, apparently, considerable difference in the initial population on the two plots. However, the population curves follow each other rather closely. Notice also the agreement in 1942.

In 1943 liquid lime-sulfur was not included in the series but a comparison was made between flotation sulfur and the wettable sulfur *Sulforon*. Neither plot received dormant oil and the low initial population was due to light oviposition in 1942 and to unfavorable hatching conditions in April of 1943. The two populations were almost identical and quite different from the population on a flotation-sulfur plot that was preceded by a dormant oil. This is shown by the dash line.

Besides the *Sulforon* used in 1943, several other wettable sulfurs were included in schedules for other seasons. The results have been very similar to those obtained with liquid lime-sulfur, flotation sulfur paste, and *Sulforon*. To summarize the experiments with summer applications of different types of sulfur, it may be said that little difference existed among the plots as far as red mite populations were concerned.

In visiting commercial orchards prior to 1939 it was frequently noticed that many well kept and well sprayed orchards were severely infested by red mite, whereas adjacent uncared-for and semi-cared-for trees were escaping injury. Prelimi-

nary work, some of which was done in Ohio as early as 1926, as well as reports from other stations, indicated that the repeated use of sulfur in the spray schedule might be responsible for this condition. Spray schedules which omitted sulfur in from two to four applications were, therefore, arranged and included in the tests.

The results obtained when sulfur was omitted from all applications following the petal-fall spray, as compared with those treated with a complete flotation-sulfur schedule, are shown in figure 2. In 1939 neither plot received dormant oil and populations at the start of the season were about equal. The wide variation in the populations on the two plots during the summer months was very striking, but no more so than was the visual appearance of the foliage. The flotation-sulfur plot was severely injured; on the other hand, the one with no sulfur in the cover sprays showed practically no trace of mite injury. The same schedules produced almost exactly the same results in 1940, although at the start of the season both plots received dormant oil. The 1941 results differ somewhat from the other seasons. The schedule with no sulfur in the cover sprays did not receive a dormant oil and started the season with a high population which continued at the same level until late August. The factors responsible for this high population of long duration are not definitely known. In 1942, as indicated by the graph, the results were similar to those in 1939 and 1940.

In 1943 a schedule in which sulfur was omitted after the calyx spray was not included in the experimental program. The broken line in the graph for that year represents the mite population on a check plot that received no sulfur at any time. The seasonal population of red mite on this plot was the lowest of any recorded during the 5-year period.

Schedules including sulfur in the first-cover spray showed a decline in mite population, but frequently sufficient numbers were present to cause foliage injury. Schedules with sulfur in two or more covers showed no reduction in mite population. Check plots that received no sulfur at any time always had the lowest population, except in a few instances where heavy initial infestations carried over from the previous year. In general, the results of numerous observations, as well as the records from the 5-year series of experiments, may be expressed as follows. The less sulfur used in the spray schedule, the less likelihood there will be of injury from European red mite.

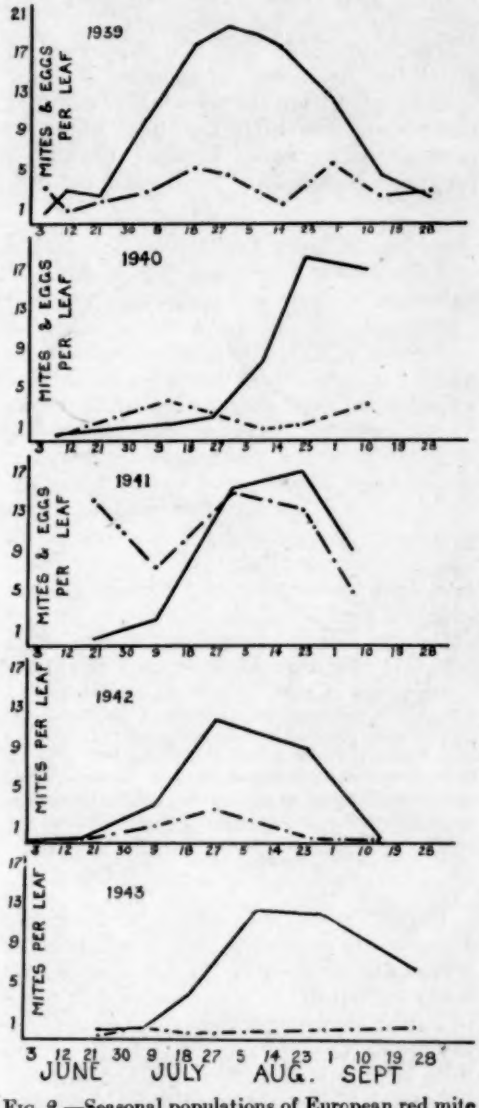

FIG. 2.—Seasonal populations of European red mite as affected by different spray schedules. Solid line: Flotation sulfur throughout growing season. Dot-dash line: (Except in 1943) no sulfur after calyx spray. Dot-dash line: (1943 only) sulfur was omitted for the entire season.

The reason for red mite abundance when sulfur schedules are used is not hard to find. At Wooster the main biological agents of control are predaceous mites of the genus *Seius*. These mites are particu-

larly susceptible to the effects of sulfur. Field counts following sulfur sprays always indicate a high mortality. While the red mite is somewhat inhibited by sulfur, high mortalities are never secured. In fact, a kill of 50 per cent is rare, even with conditions favorable for toxic effect.

The knowledge that red mite can be controlled by biological agencies if sulfur is eliminated from the schedule of summer treatments has little practical value in commercial orchards because usually a fungicide is necessary for disease control.

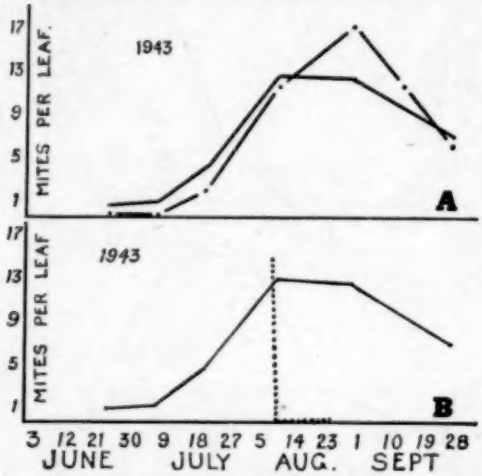

FIG. 3.—A. Seasonal populations of European red mite on plots sprayed with flotation-sulfur (solid line) and *Fermate* (dash-dot line) throughout growing season. B. Seasonal populations of European red mite with different spray schedules. Solid line represents population on flotation-sulfur plot. Dotted line shows effect of applying an efficient aracnicide in midsummer.

Recent work with the new fungicide *Fermate* has indicated that it will become a valuable addition to the list of approved spray materials. As it can be used in place of sulfur in summer spray schedules, experiments to determine its effect on red mite populations were conducted in 1943. The result of one such experiment is shown in figure 3-A. From an inspection of the graph it is evident that the effect on red mite is almost identical with that of flotation sulfur. Other tests involving *Fermate* used in combination with a sticker and with sulfurs gave similar results to those shown in the figure. It is, therefore, evident that the use of *Fermate* holds little promise in schedules for red mite control. However, summer oil used against mites does not lose its effectiveness when combined with *Fermate*.

Since other fungicides are not suited for use on apples in northern Ohio, the sulfur schedules will probably continue to be used To obtain red mite control, such a schedule should be preceded by dormant oil, and, in those seasons when populations develop rapidly, this may have to be supplemented by the use of a summer aracnicide applied when injury threatens. Of the sprays suitable for red mite control, only two are now available, summer oils and summer dinitros. Rotenone, which is effective against red mite when used with summer oil, is, of course, no longer procurable for this purpose. Summer oils should be used at from 1 to 1.5 per cent and the application must be very thorough. The dinitros should be used according to directions and the application should also be thorough. In general, the dinitros have given somewhat higher kills of mites than summer oils and are preferred under most conditions. Since the dinitros are quite effective, the question at once arises as to whether or not the dormant oil might be omitted and a dinitro used in the summer schedule when needed for mite control.

Figure 3-B illustrates the results of an experiment to answer this question. The solid line shows the seasonal mite population on a flotation-sulfur plot on which dormant oil had not been used. The dotted line shows the population on a similar plot which received an application of Dow DN-111 at 20 ounces in 100 gallons on August 7. The count made just before the plot was sprayed showed a population of 15.3 mites per leaf. On August 9 the count showed 0.1 mite per leaf and 2 weeks later the count was still only 0.3 mite per leaf. While the population increased somewhat after this last count, at no time later was there appreciable mite injury. The results of this experiment, with much supporting evidence, indicate that this type of control schedule is quite promising.—2-2-44.

Natural Enemies of Comstock Mealybug[1] in the Eastern States

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The Comstock mealybug was first given serious attention in this country as a pest of the umbrella catalpa. About the year 1934 severe outbreaks of this insect on apple began to attract attention in Virginia, and by 1939 similar infestations in apple orchards had been reported from West Virginia, Ohio, and South Carolina. In 1941 serious infestations on apple in New Jersey and Georgia and on pear in Connecticut were noted, and in 1942 outbreaks were reported on apple in Connecticut and on peach in New Jersey.

No satisfactory insecticidal control for the Comstock mealybug is known. Biological measures, however, have given satisfactory control of certain other mealybugs and, since several species of parasites were known to attack the Comstock mealybug in Japan, their importation and utilization as a possible means of controlling this new fruit pest were undertaken.

During the period 1939–41 five species of parasites of this mealybug were imported from Japan by the Bureau of Entomology and Plant Quarantine. The work involved in propagating, colonizing, and determining the establishment and value of these and other natural enemies of the Comstock mealybug has been carried on since the spring of 1940 from headquarters located at Charlottesville, Va.

Parasites Naturally Present.—In his studies of the Comstock mealybug as a pest of the umbrella catalpa in Virginia, Hough (1925) did not mention parasites among the natural enemies observed. Cox (1940) reported having reared *Clausenia purpurea* Ishii and the secondary species *Thysanus (nigra) niger* Ashm., *T. elongatus* Gir., *Pachyneuron altiscuta* How., and *Lygocerus* sp. from this mealybug in Virginia. More complete information concerning these parasites has been obtained from intensive studies made during the period 1940–42 of the natural enemies present in mealybug-infested orchards in several Eastern States.

Clausenia purpurea was described by Ishii (1923) as a parasite of *Pseudococcus* sp. on citrus in Japan. It was apparently introduced into the United States accidentally with *P. comstocki*, as indicated by the fact that it has been widely reared as a primary parasite of the Comstock mealybug in this country. It is a solitary species, never more than one adult being reared from each parasitized host. Males are rarely encountered, females being commonly produced by unmated females. Although it has been reared from nearly every orchard infested by the Comstock mealybug and is extremely abundant in many orchards, *C. purpurea* alone is not usually effective in controlling this pest during any one season, as it fails to parasitize a high percentage of the mealybug except in the third generation of the host species. Despite the extremely large numbers of overwintering *Clausenia* cocoons frequently noted, the parasitization of the first and second host generations by this species in the following year is nearly always very much lower than was anticipated, is too light to prevent a rapid build-up of the mealybug population early in the season, and thus has no appreciable effect in preventing or reducing the amount of commercial damage caused later in that season. Investigations have shown that the extent to which the overwintering cocoons are attacked by native secondary parasites, especially *Lygocerus* sp., may be the decisive factor limiting the effectiveness of this parasite.

Allotropa convexifrons, another primary parasite, was described by Muesebeck (1942) from specimens reared by George Rau in November 1938 from *Pseudococcus comstocki* at North Bergen, N. J. Apparently, therefore, this species, known to be a parasite of *P. comstocki* in Japan, may have become established in the United

[1] *Pseudococcus comstocki* (Kuw.).

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States along with its host. *A conrexifrons* is a gregarious parasite, very similar to *A. burrelli* Mues., several adults developing from each parasitized host. Attempts to introduce a breeding stock of this species into the United States from Japan in 1940 and 1941 were unsuccessful. In 1942 considerable numbers of the species were reared from Comstock mealybugs collected on pear at Greenwich, Conn., indicating its probable spread from the type locality.

INTRODUCED PARASITES.—During the period 1939–41 five species were imported from Japan through the cooperation of the Division of Foreign Parasite Introduction, of the Bureau. Stocks were increased by breeding in the laboratory, and were then colonized in mealybug-infested orchards in several Eastern States. Two species, *Allotropa burrelli* and *Pseudaphycus* sp., became well established and their colonization is being continued. The other three failed to become established and, because of the impossibility of obtaining additional stocks, further work with these has not been possible.

Allotropa burrelli was described by Muesebeck (1942). It is a gregarious parasite, an average of 11 and a maximum of 57 adults emerging from a mature host. Often from very small mealybug nymphs of earlier stages only 1 or 2 parasites are produced, the number depending on the size of the host. An average of approximately 3 females to 1 male develop. The biology of this parasite was studied in detail by Clancy (1944). During the period 1940–42 approximately 250,000 adults of *A. burrelli*, in addition to an undetermined number that emerged from approximately 33,000 parasitized hosts placed in the field, were released in 33 mealybug-infested orchards in 14 counties of Connecticut, New Jersey, Virginia, West Virginia, Ohio, and Georgia. Studies of mature female mealybugs collected subsequent to the parasite liberations have shown that *A. burrelli* has become well established at most of the colonization points. In many places it has increased rapidly under field conditions, and abundant stocks for use in extending its distribution have been readily obtained by the collection of parasitized mealybugs. The ability of this species to spread rapidly throughout an orchard from the point of liberation has been demonstrated, and there has been little evidence of attack by native secondary parasites.

Stocks of *Pseudaphycus* sp., another gregarious parasite, were first received from Japan in July 1941. An average of 6 or 7 and a maximum of 25 adults have been reared from mature parasitized mealybugs. Occasional solitary cocoons are produced from very small hosts in younger stages. An average of 3 or 4 females to 1 male develop. Owing to its short life cycle, which may require only 17 days during the summer, and to the unexpected ease with which this species can be propagated under laboratory conditions, nearly 50,000 adults became available for liberation during the remainder of that growing season, although only about 800 adults had been obtained from imported material. By the end of 1942 over 81,000 adults, in addition to an undetermined number that emerged from nearly 7,000 parasitized hosts placed in the field, had been colonized in 22 mealybug-infested orchards in 10 counties of Connecticut, New Jersey, Virginia, West Virginia, and Ohio. *Pseudaphycus* sp. has been recovered from most of the orchards in which it was liberated and has increased rapidly, especially in those areas in which it encountered comparatively little competition from other species. Its ability to spread rapidly from the point of release in an orchard appears to be at least equal to that of *Allotropa burrelli*. Unlike the latter species, however, *Pseudaphycus* is subject to severe attack by several native secondary parasites, a factor which may ultimately tend to limit its effectiveness.

During 1940 and 1941 approximately 22,300 adults of an unnamed species of *Leptomastix* from Japan were bred and colonized extensively in orchards of Connecticut, Virginia, West Virginia, Ohio, and Georgia. Although it has been recovered in small numbers at several liberation points, this parasite has failed to become established. The concentrated attack of several species of native secondary parasites was undoubtedly an important factor leading to this failure.

Approximately 11,500 adults of an unnamed species of *Allotropa*, all reared from material imported from Japan, were colonized in 1940 and 1941 in 12 orchards of 6 counties in Virginia and West Virginia. This species develops as a solitary parasite of young mealybug nymphs. Failure to re-

cover it has not been satisfactorily explained.

Two small experimental colonies, totaling 131 adults, of an unidentified species of *Anagyrus* from Japan were released in 1941 in 2 orchards in Albemarle County, Va. This parasite was recovered in small numbers from 1 orchard during that season, but apparently failed to become established.

EXTENT OF PARASITIZATION.—In evaluating the effectiveness of parasites in reducing populations of the Comstock mealybug, species already present, as well as the introduced parasites, must be considered. The parasitization in all infested orchards under observation in each of the general districts during 1940, 1941, and 1942 is summarized in table 1.

In most localities the total parasitization in any given season increased with each succeeding generation of the host. A

Table 1.—Parasitization of the Comstock mealybug in orchard infestations, 1940-42.

STATE AND LOCALITY[1]	YEAR	TOTAL REARED	TOTAL PARASITIZED	PARASITES REARED			
				Clausenia purpurea	*Allotropa burrelli*	*Pseudaphycus* sp.	*Leptomastix* sp.
		Number	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*
		First Generation Mealybug					
Connecticut:							
Greenwich	1942	263	66.5		[2]63.5	3.0	
Wallingford	1942	160	3.1	1.2		1.9	
New Jersey:							
Morganville	1942	599	5.8	.2	2.0	3.7	
South River	1942	232	6.9		1.3	5.6	
Virginia:							
Charlottesville	1940	1750	8.3	6.9	1.4		
	1941	2792	6.3	2.1	4.0		0.2
	1942	3037	41.7	14.6	21.9	5.2	
Roanoke	1940	200	1.0	.5	.5		
	1941	449	4.4	.2	4.2		
Winchester	1940	150	1.3	1.3			
	1941	997	5.0	1.8	3.2		
	1942	2014	4.2	.4	3.0	.8	
West Virginia:							
Martinsburg	1940	198	7.0	4.5	2.5		
	1941	456	4.8		4.8		
	1942	60	0				
Ohio:							
Proctorville	1942	411	2.9		1.7	1.2	
		Second-Generation Mealybug					
Connecticut:							
Greenwich	1942	53	79.2	20.8	[2]54.7	3.8	
Wallingford	1942	335	6.6	.3	[2]4.5	1.8	
Mt. Carmel	1942	90	6.7	3.3	[2]3.3		
New Jersey:							
Morganville	1942	556	35.4	3.1	8.8	23.6	
South River	1942	191	19.9	1.0	11.0	7.9	
Virginia:							
Charlottesville	1940	4457	23.3	18.2	5.0		0.1
	1941	3891	19.2	6.6	12.1	.4	.03
	1942	3804	42.2	12.7	24.0	5.5	
Roanoke	1940	76	11.8	9.2	2.6		-
	1941	113	2.7	1.8	.9		
Winchester	1940	368	7.9	.3	7.3		.3
	1941	1030	20.0	1.4	18.5	.1	
	1942	5040	19.3	1.2	10.8	7.3	
West Virginia:							
Martinsburg	1940	941	6.1	1.0	5.1		
	1941	463	7.1	.6	6.5		
	1942	266	11.3	5.6	5.6		

Table 1.—Continued

State and Locality[1]	Year	Total Reared	Total Parasitized	Parasites Reared			
				Clausenia purpurea	*Allotropa burrelli*	*Pseudaphycus* sp.	*Leptomastix* sp.
		Number	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*
Ohio:							
Proctorville	1941	653	.9		.9		
	1942	907	15.0		13.8	1.2	
Georgia:							
Cornelia	1941	190	100.0	98.9	1.1		
		Third-Generation Mealybug					
Virginia:							
Charlottesville	1940	3030	65.6	64.7	1.0		
	1941[2]	5256	38.8	26.5	10.0	2.0	0.2
	1942	1071	97.2	87.4	9.6	.2	
Winchester	1940	32	6.3	6.3			
	1941	1456	53.0	20.7	31.9	.2	.1
	1942	866	87.4	37.9	39.7	9.8	
West Virginia:							
Martinsburg	1941	260	55.0	26.5	28.5		
Ohio:							
Proctorville	1941	659	2.0	.3	1.2	.3	.2
	1942	743	91.9	3.9	78.2	9.8	

[1] Includes orchards in nearby localities comprising the general orchard district.
[2] There is considerable doubt as to the specific identity of the *Allotropa* sp. reared from Connecticut in 1942.
[3] Also 0.02% *Anagyrus* sp.

general increase in total parasitization over the entire period covered by the observations is also apparent for the Virginia, West Virginia, and Ohio districts in which work has been under way for more than one season. The only exception is the Roanoke, Va., district, which had extremely light mealybug infestations in 1941 and 1942. The infestation at Martinsburg, W. Va., was also very light in 1942; therefore no records were obtained from that district after the second generation.

In the Charlottesville, Va., district the high rate of parasitization attained on the third generation of the host was due chiefly to *Clausenia purpurea*, which is very strongly established in that area. Although of minor importance on the early generations, this parasite became of decided value there in reducing the numbers of third-generation female mealybugs, which would otherwise have produced overwintering eggs. *C. purpurea* was already so abundant at Cornelia, Ga., when the infestation was first noted in 1941, that introduced parasites had little chance of becoming established; in fact, the mealybug infestation practically disappeared before the end of that season. Undoubtedly this was due chiefly to the high parasitization by *C. purpurea* to the second generation of the host, and indicates that under the conditions existing in Georgia this parasite was able to reduce the host population early in the season.

It is readily apparent that the introduced Japanese species *Allotropa burrelli* and *Pseudaphycus* sp. are rapidly increasing in most of the districts in which they have been colonized. Their increase has been most rapid in districts such as Morganville and South River, N. J., Winchester, Va., Martinsburg, W. Va., and Proctorville, Ohio, were competition by *Clausenia* has been least. Driggers and Hansens (1943) have recently presented a detailed discussion of the situation in New Jersey. Although parasitization by the genus *Allotropa* was exceptionally high at Greenwich, Conn., in 1942, there is some question as to which species was responsible. All adults reared from Connecticut were at first identified as *A. burrelli*, but a recheck later of the few specimens that were retained showed these to be *A. convexifrons*. The latter species apparently spread naturally from the type locality, North Bergen, N. J. Although *A. burrelli* was released at Greenwich in 1941 and 1942, it is not known whether that species became established there.

The very high average parasitization of third-generation mealybugs in the Winchester, Va., and Proctorville, Ohio, districts in 1942 was due chiefly to the introduced species, which supplemented the parasitization by *Clausenia*. That the colonization program has been very effective in increasing parasitization is further indicated by the fact that 92.1 per cent of the 38 orchard blocks surveyed in 1942 had 80 per cent or more of the third-generation mealybugs parasitized, as compared with 15.4 per cent of 26 orchard blocks and 30.8 per cent of 13 orchard blocks surveyed in 1941 and 1940, respectively. In 1942 all but 9 of the blocks had over 90 per cent of the third-generation mealybugs parasitized.

EFFECT OF PARASITES ON MEALYBUG DAMAGE.—With the exception of the infestation at Cornelia, Ga., in 1941, parasitization by *Clausenia purpurea* alone has had little if any noticeable effect in reducing the amount of mealybug damage to apples during any one season. This is due to the fact that injury to the fruit is usually caused chiefly by mealybugs of the second generation, whereas maximum parasitization by that species usually occurs on the third generation of the host species. The extremely high parasitization by *C. purpurea* in female mealybugs of the third generation, resulting in scarcity of overwintering egg masses in several of the older infested orchards in the Charlottesville district, has, however, been observed to effect considerable reduction in mealybug damage the following year.

In a number of individual orchards the introduced parasites, particularly *Allotropa burrelli*, have parasitized many more than 50 per cent of the mealybugs of both the first and second generations. In certain instances the resulting reduction in mealybug population noticeably lessened the damage which would otherwise have been caused to the fruit that season.

PREDATORS NATURALLY PRESENT.—Among the insects naturally predaceous on this mealybug, Hough (1925) mentions the larvae of *Chrysopa rufilabris* Burm. and *Hemerobius stigmaterus* Fitch, which he observed occasionally attacking the younger stages of the Comstock mealybug in Virginia. Upholt (1941) records the predaceous mirid bug *Eurychilopterella luridula* Reut. as effecting appreciable control of this mealybug on apple in South Carolina in 1941, and specimens of this mirid have been encountered in nearly all Virginia apple orchards during the present investigations, it being particularly numerous in certain orchards most heavily infested by *Pseudococcus comstocki*. No definite information has been obtained regarding the possible effectiveness of this hemipteron on mealybug populations. Larvae of a cantharid beetle, *Chauliognathus* sp., are occasionally observed feeding on mealybug eggs and nymphs and on the pulp of decaying apples, and the coccinellids *Scymnus* (*Pullus*) *creperus* (Muls.) and *Scymnus* sp. are frequently found associated with mealybug infestations. Other general predators on record are *Chrysopa nigricornis* Burm., *C. quadripunctata* Burm., *Sympherobius amiculus* (Fitch), *Allograpta obliqua* (Say), and the dipteron *Leucopis bella* Loew, which has been recorded only from New Jersey. No noticeable reduction in mealybug population due to the work of predators has been observed by the writers.

EXPERIMENTAL RELEASES OF CRYPTOLAEMUS MONTROUZIERI MULS.—This Australian ladybeetle is known to be an important factor in the control of several species of citrus-feeding mealybugs in California, therefore experiments to determine its possible value as a predator of the Comstock mealybug were conducted in three apple orchards in Albemarle County, Va., during 1940 and 1941. The beetles were purchased from a California insectary and released as adults. Following the liberation, burlap bands were placed on a number of the trees in each block, frequent examinations were made to determine the status of the predator and its effect on the mealybug population, and records of mealybug injury to the fruit in the experimental blocks were compared with those in adjacent areas immediately prior to harvest.

One experiment in 1940 was conducted in a block of 100 Winesap and Pippin trees at Batesville. A total of approximately 12,900 beetles were liberated in 2 releasements, the first on July 17 at the rate of about 80 beetles per tree, and the second on August 2 at the rate of approximately 49 beetles per tree. The only recovery was 1 immature *Cryptolaemus* larva found on September 9, and no evidence of predaceous activity by the introduced beetles was observed.

On July 24, 1940, 8680 beetles were released at Covesville in a block of 100 Winesap trees in an orchard that was severely infested with second-generation mealybug nymphs of the first and second instars. The released beetles were still active at least until July 29, their progenies were observed from August 7 to October 11, and considerable evidence of predaceous activity was noted during that period, especially among the egg masses of the third brood of mealybugs. The predators had no noticeable effect, however, on reducing the heavy mealybug population or the resultant severe injury to the fruit.

In the experiments mentioned, the ladybeetles were not released until 50 per cent or more of the eggs of the second-generation mealybugs had hatched. To determine whether the predator might be able to increase faster and exhibit greater effectiveness if released much earlier in the season, approximately 4703 *Cryptolaemus* adults were released on May 28, 1941, in 100 Pippin and Winesap trees in a Batesville orchard having a very severe infestation of first-generation mealybugs, then chiefly nymphs of the third instar. The liberated beetles remained active at least until June 5, but no progeny or evidence of predaceous activity traceable to *Cryptolaemus* was observed. In each of these experiments conditions appeared favorable for development of the predators. An abundant mealybug population was present, the beetles were vigorous and active when released, and no sprays were applied in the experimental blocks immediately prior to, or at any time following, the liberations. There was no evidence that this predaceous species survived the winter at any of the liberation points. The results obtained indicated that *Cryptolaemus montrouzieri* cannot be considered an effective predator of the Comstock mealybug, at least under conditions prevailing in apple orchards in Albemarle County, Va.

FUNGUS DISEASE.—Cox *et al.* (1943) have recently called attention to the importance of an unidentified entomogenous fungus in Virginia apple orchards, and Charles *et al.* (1941) and Harrar and McKelvey (1942) successfully cultured the organism and utilized it in experiments under greenhouse conditions. In certain respects this pathogen resembles *Entomophthora fumosa* Speare, which is credited with the natural control of the citrus mealybug, *Pseudococcus citri* (Risso), in Florida (Speare 1922).

From time to time the authors observed that large numbers of mealybugs had been killed by a fungus disease. Detailed information on the prevalence of the fungus, however, is available only from collections of mature living female mealybugs obtained periodically in 1941 and 1942 for parasite-survey purposes. Although the fungus caused considerable mortality of adults in certain orchards, the averages are uniformly low, particularly as compared with the parasitization recorded in table 1. For example, during 1941 only 1.5 per cent of all the adult female mealybugs collected in the Charlottesville, Va., district became diseased, the maximum being 3.9 per cent for the second generation. In the Winchester district barely 0.6 per cent of all adult females collected were killed by the fungus, with a maximum mortality of 1.0 per cent from that cause for the third generation. The mortality from disease among mature mealybugs increased to 4.4 per cent (maximum 7.1 per cent for the third generation) and 0.9 per cent (maximum 1.9 per cent for the third generation), respectively, in the same districts during 1942. The survey collections indicated that in both years a great many more of the mature female mealybugs were killed by parasites than by the fungus. The observed sporadic destruction of large numbers of immature mealybug nymphs by the fungus during warm periods of prolonged high humidity is believed to be more or less equaled by the much steadier effect of parasitization, because many immature individuals are also killed by the parasites before attaining maturity. Although outbreaks of this fungus are frequently spectacular, and sometimes effect a marked reduction in mealybug populations, the parasites are much less dependent on suitable weather conditions, and are therefore more consistently effective in reducing the host population and keeping it at a low level.

An interesting comparison is afforded by the Charlottesville, Va., district during 1942, when most of the mealybug nymphs in the third generation and many of those that developed late in the second generation were killed by an epidemic of the fungus. Despite this extreme reduction in host

population, no less than 97.2 per cent of the third-generation females that survived to the adult stage and would otherwise have deposited overwintering eggs were parasitized. Had not these been destroyed by parasites, a sizable nucleus of mealybugs would have persisted, for increase the following year. Working together, however, the two natural control factors succeeded in almost eliminating the mealybug from this area.

Similar collections of adult female mealybugs obtained from several other States have also yielded typical fungus-killed specimens similar to those found in Virginia. The pathogen appeared to be most prevalent in the Proctorville, Ohio, district during 1942, as 9.0 per cent of the second-generation and 17.4 per cent of the third-generation hosts received from there were diseased. In the vicinity of Martinsburg, W. Va., mortality due to the fungus has remained about the same as that recorded in the Winchester, Va., district. Only a trace of the fungus appeared in the New Jersey collections, and none has yet been observed from Connecticut.

SUMMARY.—Because of the increasing importance of the Comstock mealybug as an orchard pest, investigations of its natural enemies have been carried on since 1939. Two species of primary parasites were found to be naturally established in mealybug-infested orchards. Of these, the solitary species *Clausenia purpurea* Ishii has been reared from nearly every orchard surveyed and, although extremely abundant in many orchards, is subjected to severe attack by secondary parasites. A gregarious species, *Allotropa convexifrons* Mues., has been reared from northern New Jersey and southwestern Connecticut.

Of five species of parasites imported from Japan from 1939 to 1941 and colonized widely, two gregarious species, *Allotropa burrelli* Mues. and *Pseudaphycus* sp., have become generally established in mealybug-infested orchards, have shown an ability to increase and spread rapidly, and have been very effective in increasing the total parasitization in most of the areas in which they have become established. Some reduction in mealybug damage to apple fruit has been observed in orchards where the mealybug population was reduced by high parasitization.

Although several species of insects are known to be predaceous on this mealybug, they have not been observed to effect a noticeable degree of control. Experimental mass releases of the ladybeetle *Cryptolaemus montrouzieri* Muls. indicated that this predator was ineffective against the mealybug in Virginia.

An unidentified entomogenous fungus frequently kills large numbers of mealybugs in Virginia apple orchards, but because of its dependence on favorable weather conditions it cannot be relied on to effect satisfactory control. Parasites were shown to be of more consistent value in reducing the host population and keeping it at a low level. The fungus has also been recovered from Ohio, West Virginia, and New Jersey.—3-1-44.

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Control of the Pecan Nut Casebearer with Lead Arsenate, Nicotine Sulfate, and Summer Oil

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Spraying experiments for the control of severe infestations of the first generation of the pecan nut casebearer, *Acrobasis caryae* Grote, were conducted in southern Texas in 1941 and 1942. The purpose of the experiments was to determine the relative effectiveness of nine different spray treatments, in five of which lead arsenate was used with nicotine sulfate and summer oil emulsion in one or both of two spray applications. The experiments were carried on in orchards having infestations so severe that in the absence of treatment practically no nuts were present on the trees at harvest.

Materials And Treatments.—The materials used were lead arsenate (acid), cryolite (natural), nicotine sulfate (40 per cent nicotine), summer oil emulsion (a commercial emulsion containing 83 per cent oil), and zinc sulfate. In certain spray treatments lead arsenate was used alone, and in others it was mixed with nicotine sulfate and summer oil emulsion. Lead arsenate was used at the rate of 6 pounds per 100 gallons except in certain indicated treatments in which 8 pounds were used. Thirteen fluid ounces of the nicotine sulfate and 3 quarts of the summer oil emulsion were used with it per 100 gallons. Cryolite was used with summer oil emulsion at the rate of 6 pounds of cryolite and 2 quarts of oil emulsion per 100 gallons. Zinc sulfate, 2 pounds per 100 gallons, was added to all sprays, primarily to control pecan rosette, but it also reduced the danger of arsenical burning. The check trees were sprayed with that material alone.

Methods.—In 1941, treatments were applied to three varieties of pecan, Burkett, Halbert, and Texas Prolific, in one orchard (A) and to the Burkett variety in another (B). Treatment 1 was applied on two different dates on each variety in orchard A, the minimum number of trees in any plot being 9. Other treatments in orchard A and those in orchard B were applied to non-replicated plots of 6 or more trees. In 1942, further tests were conducted in orchard A, certain treatments being replicated ten times on single-tree plots of the Burkett and Halbert varieties. All the spraying was done from the ground at a pressure of 500 to 600 pounds, a power machine and a single head gun being used. With one exception, the sprays were applied against the first generation. In 1941 the application of the first spray treatment was begun May 8, two days after approximately 56 per cent of the overwintering-generation moths had emerged in the orchard and 17 per cent of the first-generation eggs had hatched. During that year it is probable that egg deposition and hatching were delayed a few days by cool weather. In 1942 the first spray application was begun May 5, after approximately 50 per cent of the overwintering-generation moths had emerged in the orchard and 41 per cent of the eggs had hatched. One treatment (No. 4) included a third application, June 17, against larvae of the second generation.

The criteria used in determining effectiveness of the spray treatments were: (1) The percentages of nuts retained in tagged clusters of nuts after the end of the feeding period of the first-generation nut casebearer larvae and at harvest (a few days before the first-generation larvae began to feed on the newly formed nuts, serially numbered tags were placed on 50 nut clusters on each of 10 trees, a total of 1500 to 1900 nuts being included for each treatment); (2) the yields of nuts harvested from each tree used in the tests (the size of the trunk of each tree was measured and nut-yield records were calculated on a cross-sectional-area basis, which eliminates much of the variation resulting from variation in tree size); (3) the number of hibernacula formed by overwintering-generation nut casebearer larvae on trees that received various treatments (counts of such hibernacula were made in 1941).

Data pertaining to the retention and harvest yield of nuts in the plots receiving the various treatments during the two

[1] The writers are indebted to F. M. Wadley for assistance in the application of statistical methods to tests conducted in 1942, and to J. P. Hipp, L. L. Bolt, G. W. McEachern, and H. V. Rankin for assistance in taking records in the orchards.

Table 1.—Effectiveness of various spray treatments in controlling the pecan nut casebearer as determined by retention of nuts in tagged clusters and harvest yield of nuts. Crystal City, Texas, 1941.

Treatment No.	Spray Treatment		Nuts Retained in Tagged Clusters Oct. 18–19	Nut Yield Per Square Foot Trunk Section
	Application Dates	Materials		
			Per Cent	*Pounds*
		Orchard A—Burkett Variety		
1	May 8	Lead arsenate (8 lbs.)	—	36.5±3.4
1	May 12	Lead arsenate (8 lbs.)	18.0	16.6±3.1
2	May 8–9	Lead arsenate, nicotine sulfate, oil	—	42.4±5.9
3	May 9, 15	Lead arsenate	18.7	19.0±1.6
5	May 8–9, 15	Lead arsenate, nicotine sulfate, oil	56.1	67.8±4.2
Check	—	—	0.1	0.4±0.1
		Orchard A—Halbert Variety		
1	May 8	Lead arsenate (8 lbs.)	—	23.5±1.9
1	May 12	Lead arsenate (8 lbs.)	—	15.8±1.2
3	May 9, 15	Lead arsenate	—	22.2±1.5
5	May 8–9, 15	Lead arsenate, nicotine sulfate, oil	—	36.8±3.6
9	May 7–8, 15	Cryolite, oil	—	26.9±3.5
Check	—	—	—	1.7±0.1
Check	—	—	—	0.9±0.1
		Orchard A—Texas Prolific Variety		
1	May 8	Lead arsenate (8 lbs.)	—	12.4±2.1
1	May 12	Lead arsenate (8 lbs.)	—	12.4±1.7
3	May 9, 15	Lead arsenate	—	17.8±1.8
5	May 8–9, 15	Lead arsenate, nicotine sulfate, oil	—	45.0±4.1
9	May 7–8, 15	Cryolite, oil	—	7.8±1.3
Check	—	—	—	1.9±1.3
Check	—	—	—	2.0±0.3
		Orchard B—Burkett Variety		
1	May 10	Lead arsenate (8 lbs.)	—	35.1±4.1
3	May 10, 16	Lead arsenate	—	58.0±7.3
8	May 10	Lead arsenate	—	
	May 16	Lead arsenate, nicotine sulfate, oil	—	85.2±4.7
Check	—	—	—	1.7±0.3

seasons are summarized in tables 1 and 2.

RECORDS OF HIBERNACULA.—On October 21 to 24, 1941, records were made of the number of hibernacula on 1000 shoots from 10 Burkett trees which had received treatment 5 (two applications of lead arsenate and nicotine sulfate with summer oil) and on 1000 shoots from 10 Burkett check trees. Hibernacula were found on 8 per cent of the shoots of the sprayed trees and on 34 per cent of the shoots on the check trees. Although hibernacula were only one-fourth as abundant on the sprayed trees as on the checks, the number present on the former was probably sufficient to cause a severe infestation of the nut casebearer during the next season.

DISCUSSION OF RESULTS.—A heavy infestation of first-generation nut casebearers was present in the experimental orchards in both seasons, as indicated by the extremely light crop in the checks as compared with the sprayed trees. More than three-fourths of the total nut casebearer injury was caused by first-generation larvae. Second- and third-generation larvae were abundant in 1941, but they were scarce in 1942, the decrease being attributed largely to biological factors.

In all series of tests the greatest percentages of nuts were retained in the clusters and the highest yields occurred on the trees given two applications of the mixture of lead arsenate, nicotine sulfate, and summer oil. The next lower percentages of nuts and next lower yields were from trees that received this mixture in one of the spray applications, in some cases receiving lead arsenate, but no nicotine or oil, in the other application. Lead arsenate in either one or two applications, without nicotine or oil, gave general results inferior to those obtained when at least one application included the nicotine and oil. Lead arsenate, however, gave important increases in yield over the checks.

The application of a third spray of lead

Table 2.—Effectiveness of various spray treatments in controlling the pecan nut casebearer as determined by retention of nuts in tagged clusters and harvest yield of nuts. Crystal City, Texas, 1942.

Treatment No.	Spray Treatment		Nuts Retained in Tagged Clusters Oct. 13–15	Nuts Per Square Foot Trunk Section
	First Application May 5–6	Second Application May 12–13		
			Per Cent	*Pounds*
		Burkett Variety		
2	Lead arsenate, nicotine sulfate, oil	—	48.1	42.1
3	Lead arsenate	Lead arsenate	38.9	36.5
4[1]	Lead arsenate	Lead arsenate	37.3	33.3
5	Lead arsenate, nicotine sulfate, oil	Same as first application	60.0	50.7
6	Lead arsenate, nicotine sulfate, oil	Nicotine sulfate, oil	—	44.3
7	Lead arsenate, nicotine sulfate, oil	Lead arsenate	55.6	50.3
8	Lead arsenate	Lead arsenate, nicotine sulfate, oil	42.0	40.8
Check	—	—	5.0	2.1
	Difference required for significance (P=.01)		12.5	12.3
		Halbert Variety		
3	Lead arsenate	Lead arsenate	—	89.0
5	Lead arsenate, nicotine sulfate, oil	Same as first application	—	115.2
Check	—	—	—	5.2
	Difference required for significance (P=.05)			23.7

[1] Treatment included a third application, June 17

arsenate in 1942 against casebearer larvae of the second-generation did not result in increased control, but the insect was scarce in that generation that season. Cryolite with oil emulsion gave conflicting results; in one of two tests it appeared to be considerably less effective than lead arsenate.

EFFECTS OF SPRAYS ON TREES.—Observations in 1941–42 in southern Texas showed no evidence of injury to pecan trees from spray applications of lead arsenate and nicotine sulfate with summer oil emulsion. This treatment is probably unsafe on pecan foliage except in semiarid or arid climates.

CONCLUSIONS.—The data included in this paper indicate that either two spray applications of lead arsenate and nicotine sulfate with summer oil emulsion, or a first application of these materials followed by a second spray application of lead arsenate, are more effective than two spray applications of lead arsenate in the control of severe infestations of the first generation of the pecan nut casebearer.—2-25-44.

WM. M. UPHOLT JOINS THE PUBLIC HEALTH SERVICE

Dr. Wm. M. Upholt, recently located at Orlando, Florida, with the California Spray Chemicals Corporation, was sworn in as Assistant Sanitarian (Reserve) in the United States Public Health Service on July 6 and called to active duty on July 19. After a short period in Atlanta his address will be as follows:

Carter Memorial Laboratory,
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The unprecedented demand for the articles on DDT absorbed all of the separates and before we knew it all the extra copies of the JOURNAL. We must have 35 copies of the February JOURNAL, Volume 37, No. 1 to complete a standing order for libraries. It occurs to the writer that some subscribers might be willing to sell us their copy of the February 1944 JOURNAL possibly after the close of the year or after they have read and used it for reference during the year. We will be glad to pay 75¢ per copy for any that can be spared or to credit the amount on the individual's 1945 subscription.

Residual Effects of Insecticides on the Cotton Leafworm

E. E. Ivy and K. P. Ewing, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*[1]

In field-plot experiments conducted at Waco, Tex., since 1939 it has been observed that several applications of lead arsenate, applied fairly early for other insects, controlled the cotton leafworm, *Alabama argillacea* (Hbm.), throughout the season, whereas adjacent plots dusted with calcium arsenate or cryolite were slightly to completely defoliated. In 1941 it was noted that basic copper arsenate likewise had a marked residual effect against the leafworm. These observations were corroborated during the heavy leafworm infestation of 1942.

In 1942 nine field experiments were conducted in which several plots were treated with basic copper arsenate and sulfur and one plot was treated with lead arsenate. These plots were dusted from three to seven times comparatively early in the season for either boll weevil or bollworm control. In each experiment the basic copper arsenate or lead arsenate gave seasonal control of the leafworm while adjoining cotton dusted with calcium arsenate or cryolite was defoliated.

A view of a portion of one of the fields, showing complete defoliation in a calcium arsenate plot and retention of foliage in the adjoining plot dusted with basic copper arsenate, is shown in figure 1. This picture was taken on September 29, 67 days after the last insecticide application, which was made on July 24, following a total rainfall of 12.84 inches. Shortly before this picture was taken, great numbers of leafworms were observed leaving the defoliated plants in search for food and crawling over the ground of the 150-acre field in which this and two other experiments were conducted. Large numbers of larvae crawled into four 0.05-acre plots, four 0.2-acre plots, and a 4-acre plot, each of which had been treated with basic copper arsenate-sulfur. These plots were the only patches of green in the entire field, and it appeared that plants in these plots would be defoliated in a short time. However, a sufficiently toxic dose of basic copper arsenate remained on the cotton leaves to give protection, for the ground under the plants soon became covered with dead and dying leafworms, and the plants retained most of their foliage until frost. Chemical analysis[2] showed 51 times as much arsenic pentoxide (As_2O_5) and

FIG. 1.—Field view showing residual effect of basic copper arsenate against the cotton leafworm. This field was dusted 6 times between June 27 and July 24, the plot on right with basic copper arsenate-sulfur 1:1, and the plot on the left with calcium arsenate. From June 27 to September 29, when the picture was taken, the rainfall totaled 13.11 inches.

31 times as much copper oxide (CuO) in leaves from the plot dusted with basic copper arsenate-sulfur 1:1 (sample 1) as on leaves taken from a field of undusted cotton (table 1).

To obtain more detailed information on the residual effect of several materials commonly used for control of the boll weevil and the bollworm, three tests were conducted on cotton growing on the laboratory grounds. In the first test, 36 uniform plants were divided into 6 groups, the plants in each group being contiguous in a row. One group was not dusted and the other 5 groups received insecticidal treatments as follows:

(1) Calcium arsenate, containing 11.1 per cent water-soluble arsenic pentoxide (New York method) and 40.4 per cent total arsenic pentoxide.

[1] In cooperation with the Texas Agricultural Experiment Station.

[2] All chemical analyses reported herein were made by the Division of Insecticide Investigations, Bureau of Entomology and Plant Quarantine.

Table 1.—Amounts of arsenic and copper found by chemical analysis of dusted and undusted cotton leaves.

Sample No.	Treatment: Insecticide	Treatment: Number of Applications	Number of Days between Last Application and Collection of Sample	Rainfall, from First Application to Date of Collection of Sample: Total Number of Inches	Rainfall, from First Application to Date of Collection of Sample: Number of Days With 0.01 Inch or More	Content of Samples: Arsenic Pentoxide, p.p.m.	Content of Samples: Copper Oxide, p.p.m.
1	Basic copper arsenate-sulfur 1:1	6	64	13.11	19	224	372
2	Basic copper arsenate-sulfur 1:2	7	45	12.86	16	69	217
3	Check	0				4	12

(2) Zinc-safened calcium arsenate, containing 1.3 per cent water-soluble arsenic pentoxide, 42.0 per cent total arsenic pentoxide, and 3.5 per cent zinc oxide.

(3) Basic copper arsenate, containing 0.1 per cent water-soluble arsenic pentoxide, 38.7 per cent total arsenic pentoxide, and 55.1 per cent copper oxide, mixed with an equal part of 325-mesh conditioned sulfur.

(4) Lead arsenate, containing 0.47 per cent water-soluble arsenic pentoxide and 32.8 per cent total arsenic pentoxide.

(5) Synthetic cryolite, containing 87.4 per cent sodium fluoaluminate.

All dust applications were made in the dusting chamber with the dusting device described by Ivy (1943). Two applications were made, one on August 28 and the other on September 2.

A total of 1.16 inches of rain fell between the first and second applications, and during the next 5-day period (ending September 7) the rainfall was 6.93 inches. During this rainy period a heavy infestation of leafworms appeared in the cotton field in which this experiment was located. On September 7 all worms on the 36 plants were removed and counted. The results are shown in table 2. Basic copper arsenate-sulfur and lead arsenate were the most effective in reducing the numbers of leafworms, and cryolite was least effective.

In the second test a screen-wire cage was placed over each of the same 36 plants, and 10 half-grown leafworms were introduced into each cage on September 7. No additional dust applications were made, and observations on mortality were made twice daily for 5 days. The rainfall during this period of observation was 2.37 inches, or a total of 10.46 inches from August 28, the date of the first application, until completion of the test on Sep-

Table 2.—Residual effects of several insecticides on the cotton leafworm in an experiment on selected plants from the laboratory grounds.

Treatment	Rate of Application per Acre, Pounds	Test 1. Counts Made September 7, or 5 Days after Second Application of Dust[1]: Larvae per Plant Number	Test 1. Counts Made September 7, or 5 Days after Second Application of Dust[1]: Reduction, Per Cent	Test 3. Counts Made October 9, or 11 Days after Second Application of Dust[2]: Larvae per Plant, Number	Test 3. Counts Made October 9, or 11 Days after Second Application of Dust[2]: Reduction, Per Cent
Basic copper arsenate and sulfur 1:1	12	5.8	82.4	0.5	95.8
Lead arsenate	6	6.8	79.4	0	100.0
Zinc-safened calcium arsenate	6	13.7	58.5	1.2	89.8
Calcium arsenate	6	16.3	50.6	2.5	78.8
Cryolite	6	20.3	38.5	7.3	38.0
Check		33.0		11.8	

[1] Period of heavy rainfall; a total of 8.09 inches during the test.
[2] Period of light rainfall; a total of 0.55 inch during the test. Larvae were not exposed until 5 days after the second application.

tember 12. Under such severe conditions, the basic copper arsenate-sulfur caused 31.7 per cent mortality whereas there was no mortality from any of the other insecticides.

Test number 3 was started on September 23. Thirty plants were dusted on this date and again 5 days later with the same materials and in the same manner as for test 1. Cages were placed over the plants on October 3, or 5 days after the second dust application, and 10 leafworm eggs deposited in the insectary were placed on each plant. The plants were examined leaf by leaf prior to caging, and an attempt was made to remove all leafworm eggs and larvae. Some eggs obviously were overlooked, however, since an average of 11.8 larvae later developed on each of the 6 check plants. Examinations on the following days, or on October 4, showed that the 10 eggs hatched in each cage. It was impossible to recover dead first instars from the floor of the cages, therefore the method of determining the mortality was to examine the plants for live leafworms. The results of the examinations made on October 9, or 11 days after the second application, are shown in table 2.

During the period of test 3 the rainfall was much lighter than during tests 1 and 2, the total from the first dust application to the end of the test being only 0.55 inch. Under conditions of light rainfall all materials except cryolite gave fair to good control of the small leafworm larvae. Lead arsenate gave slightly better control than basic copper arsenate, and each of these gave better control than either of the calcium arsenates.

SUMMARY.—Field experiments showed that several applications of lead arsenate or basic copper arsenate dust gave protection against the cotton leafworm for more than 2 months following the last application and heavy rainfall, whereas adjacent cotton dusted with calcium arsenate or cryolite was defoliated. In cage experiments conducted on field-growing cotton which was dusted twice and exposed to 6.93 inches of rainfall after the second application, reductions in the numbers of leafworms 5 days after the second application were as follows: Basic copper arsenate-sulfur 1:1, 82 per cent; lead arsenate, 79 per cent; calcium arsenate, 51 per cent; and cryolite, 38 per cent.—3-21-44.

LITERATURE CITED

Ivy, E. E. 1943. A dusting chamber and dusting device for field cage toxicity experiments. JOUR. ECON. ENT. 37(2): 301.

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The unprecedented demand for the articles on DDT absorbed all of the separates and before we knew it all the extra copies of the JOURNAL. We must have 35 copies of the February JOURNAL, Volume 37, No. 1 to complete a standing order for libraries. It occurs to the writer that some subscribers might be willing to sell us their copy of the February 1944 JOURNAL possibly after the close of the year or after they have read and used it for reference during the year. We will be glad to pay 75¢ per copy for any that can be spared or to credit the amount on the individual's 1945 subscription.

Oil Sprays With or Without Derris Resins to Control Florida Red Scale

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In an effort to develop more effective materials for the control of the Florida red scale, the St. Lucie, Fla., laboratory of the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, has carried on experiments in which derris resins were added to oil sprays of various types. The use of derris and cube extracts with certain oils has been found to add greatly to the effectiveness of the spray mixture in the control of the California red scale, *Aonidiella aurantii* (Mask.), in California (Ebeling 1940, Cressman 1941).

Petroleum-oil sprays have been used in Florida for the control of citrus insects since about 1880. The type of oil used has varied from time to time. As a result of the work carried on by Yothers (1913 and 1918), a comparatively heavy lubricating oil was used for a number of years. More recently, the highly refined oils of light-medium viscosity have come into general use in Florida, but they have not always been satisfactory in reducing infestations of the Florida red scale, *Chrysomphalus aonidum* (L.), (Osburn 1939).

In experimental work at the St. Lucie, Fla., laboratory during the last few years an oil of 106 seconds (Saybolt) viscosity and 72 per cent of unsulfonatable residue was more effective in controlling the Florida red scale than were white oils of similar viscosities or light-medium oils containing 80 or 90 per cent of unsulfonatable residues. The control obtained from the heavier oil at safe strengths, however, could not always be considered entirely satisfactory.

Two field experiments were carried on by the writers in St. Lucie County, Fla., during 1942—one on Marsh seedless grapefruit, the other on Valencia oranges. The experimental oil was prepared with different emulsifiers and different quantities of the emulsifier, and to some of these preparations derris resins were added. In addition, commercial stocks containing light-medium, highly refined oils commonly used on citrus in Florida were included in each experimental set-up.

Procedure.—In the grapefruit experiment five different treatments were compared with one another and with a check. Four were experimental emulsions and the fifth was a commercial emulsion. The experimental stocks were made with a power mixer, and all contained oil of the following specifications:[2]

Distillation at 662° F..... 10 per cent
Viscosity at 100° F.....106 seconds Saybolt
Unsulfonatable residue..... 72 per cent.

One of the four experimental stocks was prepared with 2.5 and another with 3.5 per cent (by weight) of colloidal bentonite clay as the emulsifier. The two remaining experimental stocks were identical with the first two, except that derris resins containing 30 per cent of rotenone were added at the rate of 1 per cent of the oil content during the mixing. Before the derris resins were added to the oil they were dissolved at the rate of 15 gm. to 100 ml. of a mixture of 2 volumes of dibutyl phthalate and 1 volume of trichloroethylene.

The oil in the commercial emulsion analyzed as follows:

Distillation at 662° F.....20 per cent
Viscosity at 100° F.....68 seconds Saybolt
Unsulfonatable residue.....86 per cent.

The four experimental preparations were applied at an actual oil concentration of 1.25 per cent and the commercial emulsion at an actual oil strength of 1.66 per cent.

In the orange grove the results of four treatments involving the same oil were compared with two treatments with the same commercial oil as was used in the grapefruit grove. Two of the experimental stocks were emulsions prepared with 2.5 per cent of colloidal bentonite clay as the emulsifier, To one of these 1 per cent of derris resins, based on the oil content of the stock, was added. The two remaining experimental stocks were prepared as

[1] Minter DuPree assisted in making spray applications and in examining scales.

[2] All oils were analyzed by the Division of Insecticide Investigations of the Bureau of Entomology and Plant Quarantine.

emulsifiable oils with 1 per cent of phthalic glyceryl alkyd resin mixed with the oil before it was added to the spray tank. To one of these 1 per cent of derris resins was added. All experimental stocks were applied at an actual oil strength of 1.00 per cent. One of the commercial preparations was an emulsion, the other an emulsifiable oil. These were applied at an actual oil concentration of 1.66 per cent.

The oils in the experimental stocks used in both groves were applied at strengths of only 1.00 and 1.25 per cent, because greater concentrations may cause tree injury, whereas oils of the type in the commercial stocks can ordinarily be applied at 1.66 per cent without injury.

The experimental design in both groves was that of randomized blocks, and each block was replicated ten times, one tree in each block receiving each treatment. In the grapefruit experiment unsprayed trees were included for comparison, but in the experiment on oranges there were no check trees.

Comparisons of the effects of the treatments were made by examining 1000 adult female scales from each treatment approximately 2 weeks after the sprays had been applied. Ten leaves, each of which was infested with at least 10 adult female scales, were pulled from each of the 10 trees at different locations on the tree and brought to the laboratory, where they were examined for living and dead females under a binocular microscope. Three months after the applications, a comparison was made of the effects of the sprays on scale reinfestation, or "build-up," by examining a sample of 20 leaves taken at random from each tree. The total number of living adult female scales was recorded from one half of the top surface and one half of the under surface of each leaf. The midrib was used as the dividing line for each surface, and the combined number of scales from diagonally opposite surfaces made the total for each half leaf. Previous sampling studies had shown that the scale distribution on one half of a leaf, as just described, was about half the population of a whole leaf, with approximately the same variability. This method of sampling allowed a great reduction in microscope work with very little loss in accuracy.

RESULTS IN THE GRAPEFRUIT EXPERIMENT.—The sprays were applied in this grove on August 6 and samples were taken on August 20 and November 6. The mortality of adult female scales 2 weeks following the spray application and the reinfestation, as indicated by the number of living adult females present at the end of 3 months, is shown for each treatment in table 1.

Table 1.—Comparison of spray treatments for control of the Florida red scale on grapefruit trees, St. Lucie County, Fla., 1942.

TREATMENT WITH EMULSION OF— (QUANTITIES PER 100 GAL. OF WATER)	MORTALITY OF ADULT FEMALES ON AUGUST 20	MEAN LIVING ADULT FEMALES PER HALF LEAF ON NOVEMBER 6
	Per Cent	*Number*
(1) Water 1 gal.; Bentonite clay 7 oz.; Oil 1.25 gal.	87.5	0.03
(2) Water 1 gal.; Bentonite clay 7 oz.; Oil 1.25 gal.; Derris resins 51 gm.	95.6	.03
(3) Water 1 gal.; Bentonite clay 10 oz.; Oil 1.25 gal.	74.9	.11
(4) Water 1 gal.; Bentonite clay 10 oz.; Oil 1.25 gal.; Derris resins 51 gm.	92.5	.01
(5) Commercial emulsion applied at 1.66 per cent of actual oil	86.2	.33
Difference required for significance for odds of 19 to 1	5.6	—
(6) Check	12.3	1.50
Difference required for significance for odds of 19 to 1 (data from check included in analysis)	6.4	.53

As determined by the mortality of adult female scales on August 20, 2 weeks after the applications, the addition of derris resins significantly increased the kill resulting from the experimental emulsions (treatments 1–4). Although the use of a smaller quantity of emulsifier resulted in a significantly higher kill (treatments 1 and 3), there was no significant difference between the results from these emulsions when the same quantity of derris resins was added to each (treatments 2 and 4). The commercial emulsion used at an oil strength of 1.66 per cent (treatment 5) was significantly less effective than the experimental emulsion containing only 1.25 per cent of oil with derris resins (treatments 2 and 4) but gave as good results as or better than the same emulsions without derris resins (treatments 1 and 3). The natural mortality in the check was unusually low, and the difference in mortality between each treatment and the check was significant.

On November 6, when samples from each treatment were compared for effect on reinfestation following the applications, there was no significant difference

between them, but there was a significant difference between the infestations found on samples from any treatment and the check. Even though no real differences were found statistically, the better kills associated with treatments 1, 2, and 4 in August appeared to be reflected in the comparisons on November 6.

RESULTS IN THE ORANGE EXPERIMENT.—The sprays were applied in this grove on September 9 and samples were taken on September 22 and on December 12. The results are shown in table 2.

Table 2.—Comparison of spray treatments for control of the Florida red scale on orange trees, St. Lucie County, Fla., 1942.

TREATMENT (QUANTITIES PER 100 GAL. OF WATER)	MORTALITY OF ADULT FEMALES ON SEPTEMBER 22	MEAN LIVING ADULT FEMALES PER HALF LEAF ON DECEMBER 12
	Per Cent	*Number*
(1) Emulsion of: Water ½ gal., Bentonite clay 5½ oz., Oil 1 gal.	75.9	0.16
(2) Emulsion of: Water ½ gal., Bentonite clay 5½ oz., Oil 1 gal., Derris resins 41 gm.	94.0	.10
(3) Emulsifiable oil of: Oil 1 gal., Phthalic glyceryl alkyd resin 38 ml.	80.5	.11
(4) Emulsifiable oil of: Oil 1 gal., Phthalic glyceryl alkyd resin 38 ml., Derris resins 41 gm.	88.4	.12
(5) Commercial emulsion applied at 1.66 per cent of actual oil	76.1	.10
(6) Commercial emulsive applied at 1.66 per cent of actual oil	80.0	.04
Difference required for significance for odds of 19 to 1	8.5	—

As determined by scale mortality 2 weeks after the applications, the experimental emulsion with derris resins added (treatment 2) was significantly superior to the experimental sprays without derris resins (treatments 1 and 3) and to the commercial preparations at 1.66 per cent (treatments 5 and 6). The experimental emulsifiable oil with derris resins (treatment 4) gave better results than the same spray without derris (treatment 3), but it did not quite reach the point of statistical significance. Without derris resins the emulsion (treatment 1) was not significantly different from the emulsifiable oil (treatment 3). The experimental sprays at 1 per cent of oil concentration, either as an emulsion or as an emulsifiable oil, without derris resins, were as effective as the commercial preparations at 1.66 per cent. Comparisons to determine reinfestation, made 3 months after the sprays were applied, showed no significant difference between any of the treatments.

DISCUSSION.—Although the scale infestations were much heavier in the orange than in the grapefruit trees at the time the spray applications were made, the lower concentrations of oil plus derris resins used in the orange grove were nearly as effective in causing mortality as were the heavier concentrations applied to the grapefruit trees. This showing was due to the derris resins, because it was not generally true of the lower concentrations of oil containing no derris. Generally, the living female-scale infestations 3 months after applications were at a low level in both groves, and the experimental sprays without derris resins prevented reinfestation about as well as did sprays containing them, and were as effective in that respect as the commercial sprays used at a higher concentration. The experimental emulsive stocks were much easier to prepare than the stock emulsions, as no power equipment was needed for mixing the emulsifying agent with the oil. The experimental sprays at 1.25-per cent concentrations without derris resins were much cheaper, costing about 45 cents per 100 gallons, than the commercial sprays of highly refined oil used at 1.66 per cent, which ranged in price from $1.00 for the commercial emulsive oil to $1.30 for the commercial emulsion per 100 gallons. No injury to trees or fruit resulted in either grove from the use of any of these spray materials.

SUMMARY.—Sprays of petroleum oil made emulsifiable with phthalic glyceryl alkyd resin and with different amounts of colloidal bentonite clay were compared with the same oil sprays containing derris resins and with commercial oil stocks for the control of the Florida red scale, *Chrysomphalus aonidum*, in grapefruit and orange trees.

The addition of derris resins to oil sprays increased scale mortality, as determined by results taken 2 weeks after application. A stock emulsion prepared with 2.5 per cent of bentonite killed more scales than one made with 3.5 per cent of the same emulsifier, but when the same amount of derris resins was added to each of these stock emulsions there was no significant difference in mortality from

sprays containing different quantities of the emulsifier.

The experimental emulsifiable oil with derris resins gave better results than the same spray without derris, but it did not quite reach the point of statistical significance. In general commercial stocks at concentrations of 1.66 per cent of oil were no more effective than experimental stocks without derris resins applied at strengths of 1 or 1.25 per cent.

A comparison of samples from each treatment 3 months after the sprays had been applied failed to show any significant difference in infestations of living adult female scales, indicating that the significantly higher mortalities associated with some treatments immediately after applications did not significantly affect reinfestation.—3-15-44.

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Observations on Bee Repellents

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In the spring of 1943, with the cooperation of the Department of Pomology, the authors conducted some tests to determine the repellent value of some of the common materials that have been suggested as possible bee repellents.

For some years experiments have been conducted here testing the value of bee repellents. From these earlier tests, three materials were selected as being of possible value; namely creosote, carbolic acid and a proprietary phenol compound known as *Milkol*. Of the three, creosote seemed to have the best possibilities.

Some beekeepers have recommended the addition of such materials to the ordinary spray mixtures at the rate of 1 pint to 100 gallons of spray solution. The evidence that can be obtained as to the value of such practices is difficult to evaluate. Most of the information has not been based upon controlled experiments. Moreover the materials used have not given consistently similar results.

The authors conducted experiments over several years. Inasmuch as the same kinds of trees were not always available and since the materials were applied by means of a compressed air sprayer, some of the data did not check. However, several of the materials were eliminated due to their injury to the tree, their difficulty in application or their injurious effect upon the operator.

In 1943 a row of 10 trees of the same variety, Cortland, was made available for tests. These trees received the pink spray consisting of 6 pounds flotation sulfur, 6 pounds lime and 3 pounds lead arsenate per 100 gallons of spray solution. The spray was applied with a power outfit using a quad nozzle and a pressure of 375 pounds. The application was made on May 17.

Applications were made on May 22 using carbolic acid and *Milkol* at the rate of 1 pint per 100 gallons of spray solution. Creosote was also included in the experiments at various rates. The effects of the addition of lime to the creosote mixtures were noted. Also in order to overcome the difficulty of mixing creosote with spray solutions some tests were included to show the effect of the addition of wetting agents.

The experiments were made with the following points in mind:

1. Effect of bee repellent and spray mixture on all parts of trees.

2. Effectiveness of repellent in keeping bees from sprayed bloom.

3. Comparison of crop from portion of

Table 1.—Bee repellent tests, 1943.

May 22 Materials in 100 Gallons	Temp. °F.	R.H.	Weather	Injury May 23	Injury May 24	Injury May 25[1]	Injury May 27
1. Lead arsenate 3 lbs. Flotation sulfur 6 lbs. Creosote 0.5 pint	D53	88%	Cloudy Mod.–strong NE wind	75–90% blossom injury; browned petals	No foliage injury	Bloom gone on sprayed side. 20–25% on unsprayed side still left	Injury not increasing
2. Lead arsenate 3 lbs. Flotation sulfur 6 lbs. Creosote 1 pint	D53	88%	As above	90–100% blossom injury; browned petals	Distinct leaf injury, leaves appear slightly browned	As above. Leaf injury more apparent	Not much change Injured leaves drying
3. Lead arsenate 3 lbs. Flotation sulfur 6 lbs. Creosote 1 pint Lime 6 lbs.	D53	82%	Clearing	30–40% blossom injury; petals curled	Slightly more blossom injury. Many petals on unsprayed half of tree have dropped	As in #1 for blossoms. Slight leaf injury	No change
4. Lead arsenate 3 lbs. Lime-sulfur 1 gal. Creosote 1 pint	D52	82%	Cloudy	40–50% blossoms browned; petals curled	Slight trace of leaf injury. Leaves turn downward	Crinkling and cupping of many leaves. Midvein appears blackened	Injury more apparent. Margin of leaves yellowed. Some leaves cupped and brown
5. Lead arsenate 3 lbs. Flotation sulfur 6 lbs. Creosote 1 pint Ultrawet 2 oz.	D51.5	84%	Cloudy	35–45% blossom injury	Similar to that of May 23. Some bees working sprayed side	No evidence of leaf injury yet	About as in previous day
6. Lead arsenate 3 lbs. Flotation sulfur 6 lbs. *Aresket* 2 oz. Creosote 1 pint	D52	82%	Cloudy	35–45% blossom injury	Similar to conditions observed on May 23	No evidence of leaf injury. Not quite as much bloom on sprayed side	No change
7. Lead arsenate 3 lbs. Flotation sulfur 6 lbs. *Milkol* 1 pint	D53	82%	Clearing	10–20% blossom injury. Bees seem to work all parts normally	No further injury. Bees working both sides well	No evidence of leaf injury. Bloom about evenly distributed	Leaves about same on both sides of tree
8. Lead arsenate 3 lbs. Flotation sulfur 6 lbs. Creosote 2 pints Lime 6 lbs.	D53	82%	Clearing	60–80% blossom injury	Some leaf injury beginning to appear	Leaf injury more apparent. Diffuse browning. Not cupping	Injured leaves drying. No increase apparently
9. Lead arsenate 3 lbs. Flotation sulfur 6 lbs. Carbolic acid 1 pint	D53	82%	Clearing	10% blossom injury. Bees seem to be working normally	Both sprayed and unsprayed trees similar in appearance. Bees working on both sides	Both sides about normal in appearance	A few slightly yellowed leaves
10. Check				O.K.	O.K.	O.K.	O.K.

[1] No data on May 26. Heavy rain. By May 28 no more injury. Trees seem to be growing out of injury.

tree receiving repellent and that receiving normal spray mixture.

The procedure followed was to spray the west side of each tree with its selected mixture. Following this the east half of each tree was sprayed using a standard spray mixture without any repellent. Records were taken of the temperature, relative humidity and condition of weather. This information together with that of the various spray mixtures is recorded in table 1. Temperature and precipitation records for the entire period appear in table 2.

While the relative humidities were high, the temperatures were sufficiently low to preclude any serious burning. This was evidenced by the condition of the check as well as that of the portion of the tree not receiving the repellent. The data ob-

Table 2.—Temperature and precipitation records May 18–May 27.

	Temperature			Precipitation			
	Max.	*Min.*	*Mean*				
May							
18	77	62	69.5	Above 65	10A–12P	0.65	9–12P
19	79	71	67	Above 65	8A–8P	.17	9–12P
20	70	53	61.5	Above 65 from	9A–2P	.29	0A–8A
21	56	52	54	Poor for flight		.75	8A–12P
22	62	47	54.5	Poor for flight		.17	0A–8P
23	77	40	58.5	Above 65 from	11A–7P		
24	77	49	63	Above 65 from	11A–7P		
25	72	48	60	Above 65	9A–8P		
26	68	58	63	Above 65 from	11A–6P	0.72	3A–9P
27	79	52	65.5			.05	3P–4P

Table 3.—Fruit harvested.

TREATMENT NO.	DROPS (APPLES)			PICKED FRUIT—BUSHELS		
	East Side Untreated	West Side Treated	Per Cent from Sprayed Side	East Side	West Side	Per Cent from Sprayed Side
1	127	42	24.8	8	7	46.6
2	84	100	54.3	7	8	53.3
3	140	75	34.8	9	7.75	46.2
4	67	34	33.6	8	8.25	50.7
5	101	164	61.8	6.75	8.5	55.7
6	223	113	33.6	6	7	53.8
7	198	92	31.7	7.5	7	48.2
8	148	42	22.1	8	5.5	40.7
9	130	61	31.9	7.25	6	45.2
Check	158	91	36.5	4.5	4	47
Total excluding check	1218	728		67.5	65	
Total including check	1376	814		72	69	

tained concerning injury appear in tables 1 and 2.

The most apparent result of the application of the various repellents was the blossom injury caused. This appeared in all treatments but varied in intensity from 10 to 100 per cent. The injury was indicated by a curling and browning of the petals. This injury usually appeared within the first 24 hours following application. In a few cases it seemed to increase after the first 24 hours. The petals dropped sooner on the side of the tree treated with the repellent.

There was some leaf injury. The amount of type varied somewhat. In some instances, the damage was evidenced as a browning and eventual drying of the leaf tissues. In other instances the midveins appear blackened and this was followed by a cupping and crinkling of leaves. Unfortunately on the fourth day following the application a heavy rain occurred (0.72″ in one continuous storm). Following this, no further injury was noted and the trees seemed to improve in appearance.

The trees received subsequently curculio and apple maggot sprays. They received no further treatments. At harvest time, the drops were collected from the respective halves of the trees and individual apples were counted. The fruit was picked carefully and the number of bushels recorded. Table 3.

DISCUSSION.—In most instances there were fewer drops on the side receiving the repellent. However on the basis of picked fruit, there was within 2.5 bushels as many apples on the treated as on the untreated portions of the trees. In 5 treatments there was more fruit on the side not receiving the repellent. In 4 treatments there were more apples on the side receiving the repellent.

From the data obtained in these experiments the following observations can be expressed.

1. Under the conditions of the experiment, the addition of creosote to the spray mixture invariably produced blossom injury. In this particular test the resulting crop of fruit probably was not sufficiently decreased to cause concern. However if the application had been applied at a different time, the results that might have occurred are problematical.

2. The value of the materials used as repellents is questioned since the data obtained do not indicate any great reduction in the amount of fruit produced on the treated side as compared with that produced on the untreated side. Moreover, observations on bees actually working on the treated and untreated portions indicated that within one day's time, there were relatively as many bees on the treated as there were on the untreated portions provided there were any blossoms left that could be worked.

3. The addition of lime appeared to reduce the foliage injury caused by the creosote.—2-23-44.

The Role of Bees in the Production of Fruit and Seed

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It should not be necessary to remind any group of biologists, whatever their specialty, that there exist in the plant kingdom modes of reproduction which are as essential and involved as any in the animal kingdom, and that certain species of plants are dependent on insects for their ultimate fruition and perpetuation.

Every biologist further knows that many economic plants can produce seed and fruit only through cross-pollination, and that the pollination even of some self-fertile species is effected only by insects. Insects also play a part in the pollination of a few wind-pollinated plants, but their role is minor in the pollination of corn, wheat, and other cereals, and most anemophilous plants. Entomologists, however, in their concentration on injurious insects have almost disregarded the use of pollinating insects as a means of increasing the production of many fruit, garden, and seed crops.

The unprecedented wartime demand for foods of all kinds has focused attention upon the importance of the beekeeping industry in the production of many food crops. The beekeeping industry has been looked upon chiefly as a source of honey and beeswax; consequently, early in this war it received little consideration in the assignment of priorities on manpower and strategic materials. Fortunately, many of the war agencies soon realized that beekeeping must be safeguarded if food production, so far as it was affected by pollination, was to be maintained.

The ultimate objective of economic entomology is to increase the production of farm, garden and orchard crops, livestock products, and fibers, and to safeguard the health of man and generally to enhance his comfort and well-being. Many entomological projects are directly concerned with increasing production through the control of destructive insects; yet the possibilities of bettering production through the planned use of beneficial insects, other than parasites, have been largely overlooked.

For example, a good stand of red clover carries enough blossoms to produce 10 to 12 bushels of seed per acre, and in certain places such yields have been obtained, but the current average production in the United States is only 0.89 bushel per acre. Similar comparison can be made of seed production in other legumes. There is, of course, a wide difference between the average production and the possible or optimum production of any crop. Nevertheless, the opportunities for increasing production are being lost through indifference to the conservation and propagation of wild pollinating insects and to the scientific and strategic use of honeybees. The difference between 1 bushel and 12 bushels of seed per acre creates a problem requiring the attention, not only of entomologists, but of agronomists and others as well.

There is a heavy demand for legume seed, a demand that will continue long after the war. The problem of inadequate insect pollination existed before the war. It has become intensified during the war and will continue after the war.

Many experiments have been performed, using trees and other plants from which pollinating insects have been excluded by means of screen cages, to determine the degree to which pollination is dependent on insects. With most plants that require cross-pollination the results have been so positive as to leave no doubt as to the role of such insects. With many species no seed or fruit is formed when insects are excluded from the blossoms. Nearly all kinds of apples require insect pollination. All varieties of almonds and sweet cherries are self-sterile. Most Japanese plums are self-sterile with much interincompatibility among varieties. Such plants must be pollinated either by hand or by insects; there is no alternative. The former, of course, is costly and in many cases impracticable.

Cage experiments are rightly being continued, for too little is known about the pollination requirements of many species and varieties. Even with the same species pollination may differ in different localities. One variety of grape, for example, may be self-fertile in one place but require cross-pollination when grown in another locality. In spite of an accumulation of

data of this sort, there are still no comprehensive research projects under way, commensurate with the importance of the problem, that aim to increase seed or fruit production by correcting the deficiency in pollination.

Increase in production has not always followed when bees have been moved within flight range of a crop requiring insect pollination. In such cases it has been easy to jump to the conclusion that bees were not the answer. Rarely has enough consideration been given to the competition among plants for flower-visiting insects. For example, if mustard is used as a cover crop in a pear orchard and the two blossom simultaneously, the pear blossoms may receive little attention from the bees because the nectar of the mustard contains several times as much sugar as does the pear nectar. Pollination is thus complicated, and the problem has to be solved through some means other than merely placing bees close to the trees.

Much planting of fruit crops and harvesting of seed crops have been done with little thought to the effect of the proximity of one crop to another. Alfalfa grown in this country is largely dependent upon insects for pollination. If it is grown under conditions that do not favor a copious secretion of nectar, the blossoms may be attractive to insects only because of the pollen. If corn happens to be in tassel in the vicinity of alfalfa in full bloom, bees will desert the alfalfa for the corn. The latter produces pollen in more abundance than do the tiny blossoms of alfalfa, and it is more accessible to the bees. Competition among plants for bee visitors will unquestionably explain many cases of luxuriant plant growth followed by seed failure. Certainly the pollination requirements of a crop and the possible effect of competing crops should be considered in advance of planting and harvesting.

The phenomenon of nectar secretion needs to be studied because of its fundamental bearing on the attraction of pollinating insects. Undoubtedly much can be done to increase productiveness by selecting and breeding plants that have nectar of a high sugar content which is easily accessible. In the planting of crops thought should be given to their ability to secrete nectar and to furnish pollen. There is reason to believe, for example, that pollination of alfalfa is interfered with when it is grown close to sweetclover. The latter, grown either intentionally or as a volunteer, is almost without exception more attractive to insects seeking either nectar or pollen. This well illustrates why pollination problems cannot be solved by studying the crop alone. An ecological study of the immediate locality has to be considered.

The pollination of seed and fruit crops has been seriously hurt by the widespread use of insecticides. Whenever poisons are applied to plants, particularly in the flowering stage, pollinating insects are destroyed. The problem is an old one, and as more and more insecticides are being used wild pollinating insects are gradually being eliminated. In some places they have already become so scarce as to be inconsequential. In areas where insecticides are being used intensively, beekeepers are compelled to give up beekeeping or to move their apiaries out of range of the poisoning. Zealousness to get a job done and to find a means of control perhaps accounts for the fact that too few entomological experiments or control measures take into consideration the possible harmful effects of contemplated measures calling for the use of insecticides.

Seed production of many of the legumes that depend upon insect pollination has steadily decreased in spite of all efforts of agronomists, plant pathologists, and entomologists to stop the downward trend. In Utah the annual production of alfalfa seed decreased from 23,232,000 pounds in 1925 to a current 3,660,000 pounds. This decrease certainly is not all a matter of pollination, nor is the reduction of pollination due entirely to the use of insecticides. When the effect of insecticides on honeybees has been questioned, however, the owner of the bees and the value of his honey and beeswax have been considered of little importance in comparison with the crop being protected by insecticidal means. Only when man or livestock is endangered has the hazard of too free use of insecticides and other poisons been emphasized.

Little thought has been given to the conservation of bumblebees, solitary bees, and other wild pollinating insects, which feed almost entirely on pollen and nectar. Most wild pollinating insects are more effective pollinators, bee for bee, than are honeybees. Because of the decimation of

wild bees, much pollination is now performed by honeybees. In several studies honeybees were found to be responsible for upwards of 80 per cent of the pollination, however inadequate it might have been. In areas of intensive agriculture extinction awaits the wild pollinating insects if steps are not taken to conserve them.

The depopulation of pollinating insects has been brought about by factors other than the use of insecticides. The planting of large areas in single crops has deprived the native bees of a succession of food plants and of suitable nesting places. Practically none of the wild pollinating insects are able to store food for a period sufficient to bridge over a severe dearth or a long gap in the flowering period, such as occurs in large unmixed plantings. Starvation is the result. Forest and brush fires, clean fence rows, clean cultivation, and other modern agricultural practices take their toll of ground-nesting species.

Honeybees have not yet shared the fate of wild pollinating insects in certain areas where intensive agriculture is practiced, luckily because the queen bee is seldom poisoned. Partly for this reason, a colony may linger and die slowly, and in some cases may even recover. In extensive dusting operations, often involving the use of airplanes, the colony may be destroyed very quickly, but in most cases the loss of bees is so gradual as often to be attributed to causes other than poisoning.

Honeybees can be moved out of flight range of poison. This is not a happy solution, since the practice curtails pollination. Beekeeping might be safeguarded to a certain extent through the use of smaller quantities of insecticides or less toxic ones or by changing the method of application. Another, but more difficult, solution would be to develop fruits, vegetables, and forage crops that are both self-fertile and self-pollinated. Such a development would exclude the use of hybrid vigor, a condition that appears most desirable in bringing about improvement in many crop plants. The problem is complicated and closely intertwined with all branches of agriculture.

Better control, but more especially, perhaps, closer supervision, of the use of insecticides deserves consideration. All concerned with using insecticides, and particularly those who recommend their use, should remember that the materials are applied because they are toxic to insects. They should be applied only where and when they will be effective against the pest to be controlled. Thoughtless and careless use may cause losses even greater than those caused by the pest. Pollinating insects are needed to assure the production of many fruit, forage, and vegetable seed crops. To protect the crops, insecticides should be applied with care to the infested fields or area and in a manner to prevent drift into adjacent areas.

The destruction of bees has become so serious in certain areas that beekeepers and beekeepers' organizations are now seeking redress through legal means. Such a procedure may have far-reaching effects. To what extent, for example, is a person justified in protecting his crop through the use of arsenicals if by so doing he destroys the wild pollinating insects not only on his own land but on the lands of his neighbors, and in addition compels beekeepers to move their apiaries out of flight range of the crop? To deprive a farming community of pollinating insects must be as serious an offense as to permit unchecked the ravages of destructive insects.

Undoubtedly this problem would have come to a head long ago were it not for the fortunate fact that poison-laden bees die before they deposit poisonous nectar in the hive. If there were the remotest possibility of poisonous honey getting on the market, its sale would be stopped immediately, and as a food product it could be sacrificed if necessary. If people stopped buying honey, the keeping of bees would be stopped, and without beekeeping deciduous fruits would become rare, the seed of many legumes would be almost prohibitive in price, there would be fewer cucumbers, melons, and squashes, and production of cottonseed and lint would be lowered. About 50 crops would be seriously affected.

There is scarcely a State where crop production could not be benefited, pastures improved, and soil erosion lessened through a widespread beekeeping industry; yet few States have recognized the place of beekeeping in pollination, and few agricultural colleges and experiment stations give more than passing thought to fostering beekeeping.

In a report of the United States Agricultural Mission to Saudi Arabia for 1943 occur the following statements:

"In studying the yielding behavior of different plants in the El Katif, Hofuf and other areas growing similar crops it appears that very few fig, pomegranate, lime, citron, peach and bitter almond trees are producing as much fruit as similar sized trees in a similar climate in America. Excess shading and in some cases over irrigation account for some of the low yields but it is believed that poor pollination is a more general cause . . .

"Because the honey bee will thrive in Saudi Arabia; will probably result in an increase of all crops needing cross pollination; will pay big dividends in honey to the beekeeper; and will provide added food for the country; it is believed that they should be introduced into all the larger districts where alfalfa and other fruit, field, and vegetable crops are being grown . . ."

An agricultural mission to the United States might be in order.

Pollination, most practically applied, through the proper use of honeybees is fully as important as proper cultivation, pruning, and spraying in the growing of many crops. In the ultimate harvest the difference between complete and inadequate pollination may be greater than the difference between high- and low-yielding varieties or between approved and careless cultural practices. As long as agriculture continues to depend largely upon crops in which insect pollination is essential, the proper use of honeybees as an agronomical and horticultural practice will have to be recognized. The combined efforts of entomologists, agronomists, horticulturists, and farmers working in close cooperation can greatly improve seed and fruit production by safeguarding and utilizing the possibilities of insect pollination. Such activity should be initiated promptly.—3-3-44.

Variation in the Sugar Concentration of Some Southern Nectars[1]

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This paper presents the results of a study made in Louisiana during the years 1938–43 of the variation in the sugar concentration of nectars from a number of southern honey plants. The term "sugar concentration" is used because it has been used by other investigators. Some of the plants named in table 1, *i.e.*, goldenrod, palmetto, vervain, white clover, and white sweetclover, are major honey plants in certain parts of the South; the others are usually minor sources of nectar.

Park (1929) and Vansell (1939) have reported on the percentage of sugar in the nectar from some Iowa and western plants. They state that considerable variation occurs in the sugar concentration of a single species. The percentage of sugar in the nectar from the plants reported in table 1 also shows wide variations; the maximum frequently exceeds the minimum by two or three times. Notwithstanding the high relative humidity common to the South, the variations reported in Louisiana do not exceed those in Iowa or in the West.

[1] In cooperation with Louisiana State University, Baton Rouge, La.

Park (1939) states that relative humidity, temperature, and the plant species affect the sugar concentration of the nectar. Vansell (1940, 1941) states that the nectar from plants of the same species, growing under controlled conditions, varies widely in sugar concentration. Alfalfa blossoms, under a humidifier, produced nectar whose sugar concentration ranged from 11 to 38.3 per cent. Under field conditions the sugar concentration of alfalfa nectar ranged from 22 to 66 per cent. Vansell believes that soil moisture, relative humidity, and plant variety affected the sugar concentration of the nectar. Scullen (1940) shows that the sugar concentration of fireweed nectar in Oregon ranges from 23.5 to 65.6 per cent. Direct comparisons of environment and of sugar concentration between southern plants and those of other sections cannot be given because the environmental conditions are not known and the plant species are generally different.

METHODS.—The method used by Vansell (1939) was employed in this study. The sugar concentration of the nectars was determined by means of a refractom-

eter. Honeybees were caught on blossoms of the desired species of plants, the contents of the honey stomach of one or more bees were emptied upon the prism of the refractometer, and a reading was made. Correction for temperature deviations of the instrument was not made. A refractometer measures the "total dissolved solids" in a solution, but in nectar such solids, other than sugar, are believed to be extremely small.

RESULTS.—Table 1 gives the average sugar concentration of the southern plants under observation. In nearly one-half of the readings the average sugar concentration falls between 30 and 40 per cent.

Since the range of the readings is rather large, it seems desirable to show in more detail how the individual readings of the percentage of sugar may deviate from the arithmetic average. Table 2 gives the frequency distribution of the readings of three different years each for white clover and goldenrod and their average sugar concentrations for each year and for the three years.

Nectar from several bees captured during a 5- to 10-minute period on a single species of flower seldom showed much variation in the percentage of sugar concentration. On the contrary, samples taken at intervals during the day, or over a fairly long season, frequently showed considerable variation. Three examples are given in table 3. A representative average figure for any nectar can be obtained by taking samples at different times of day throughout the blossoming period of the plant. The practical application of these findings to beekeeping, *i.e.*, the size of the honey crop, has not yet been made.

A few general comments concerning this work on sugar concentration of nectar may be of interest to the reader. The observations reported here were incidental to a study of honey plants. Samples were not obtained unless bees were working on the flowers; therefore during periods unfavorable for bee flight few or no readings could be made. There probably was a tendency to get more samples during periods when experience indicated that bees would be working the blossoms. The period of the year affected the time of day when sam-

Table 1.—Average sugar concentration in the nectar of flowers of some southern plants.

NECTAR PLANTS	SAMPLES	SUGAR CONCENTRATION	
		Average	Range
	Number	*Per Cent*	*Per Cent*
English holly, *Ilex* spp.	58	22.8	13–37
White sweetclover, *Melilotus alba*	26	23.4	10–37
Crownbeard, *Verbesina* spp.	29	24.2	19–29
Boneset, *Eupatorium perfoliatum*	21	28.6	19–35
Satsuma orange, *Citrus nobilis unshiu*	54	30.6	19–42
Vervain, *Verbena bonariensis*	90	31.3	20–47
Blackberry, *Rubus* spp.	10	32.0	25–55
Thistle, *Cirsium horridulum*	26	32.3	20–43
Goldenrod, *Solidago altissima*	200	33.8	17–49
Palmetto, *Sabal louisiana*	26	34.6	18–44
Ligustrum, *Ligustrum lucidum*	20	35.2	12–53
Willow, *Salix* spp.	15	37.3	32–44
Sand pear, *Pyrus pyrifolia*	10	40.0	29–52
Smartweed, *Polygonum* spp.	19	41.0	33–51
White clover, *Trifolium repens*	165	43.3	14–68
Persian clover, *T. resupinatum*	21	53.0	32–64
Tung-oil tree, *Aleurites fordi*	16	54.7	24–70

Table 2.—Frequency distribution of the sugar concentration readings of white clover and goldenrod for three years and the average sugar concentrations.

CLASS INTERVAL	FREQUENCY							
Sugar Concentration (Per Cent)	White Clover				Goldenrod			
	1938	1941	1943	3 Years	1941	1942	1943	3 Years
10–19	6	0	1	7	10	0	0	10
20–29	3	5	2	10	37	1	30	68
30–39	15	22	17	54	41	27	13	81
40–49	10	18	7	35	3	39	0	41
50–59	6	20	20	46	0	0	0	0
60–69	0	8	5	13	0	0	0	0
Average sugar concentration, per cent	36.3	44.7	44.6	43.3	28.6	40.1	29.5	33.8

Table 3.—Variation in sugar concentration of nectar during the day and during the season.

PLANT	DATE	SUGAR CONCENTRATION (PER CENT) OF NECTAR TAKEN FROM BEES CAPTURED AT—				AVERAGE[1]
		9 A.M.	11 A.M.	1 P.M.	3 P.M.	
Goldenrod	10/ 8/1941	No bees working	38, 38, 42	30, 32, 32, 32,	28, 31	33.8
	10/31/1941	No bees working	36, 37, 37, 38	34, 34, 34, 36	27, 31, 32, 33	
White clover	5/21/1941	51, 52, 54			58, 58, 59, 60	43.3
	6/ 6/1941		37, 37		39, 41, 41, 42	
English holly	2/23/1944	12, 12, 14		21, 29, 29, 30, 31, 33, 34		22.8
	2/24/1944	10, 11, 12, 13, 14, 15, 18	14, 19, 20, 21, 24, 24, 26		27, 31, 31, 33, 37	

[1] From table 1.

ples could be taken. White clover is in full bloom in May, when the amount of possible sunshine ranges from 13 to nearly 14 hours per day. Goldenrod blooms in October, with 11 to 12 hours of possible sunshine daily. The relation of length of day to bee activity is shown in table 3. Environmental changes may have a greater and more immediate effect on the blossoms of some species than others. White clover blossoms are close to the ground, surrounded by many green leaves, whereas goldenrod blossoms are 3 to 5 feet above the ground, with much more open space about them. It is possible that the former plant is less affected than the latter by wind movement. The holly samples of February 24 (table 3) were taken from bees working on a single isolated tree.

All the possible reasons for the variation of sugar concentration probably have not been determined. Wind movement, soil nutrients, length of blossoming period, season of the year, and other factors may also influence sugar concentration. Much more data will have to be obtained before the effect of these factors can be studied.

SUMMARY.—The percentage of sugar concentration of nectar taken from the honey stomachs of honeybees caught on the blossoms of certain plants was determined by the use of a refractometer. The number of samples, the sugar concentration, and the range of the readings are given. English holly had the minimum average value of 22.8 per cent of sugar and the tung-oil tree had the maximum average value of 54.7 per cent. A wide range in the sugar content of nectar from the same plant species is common, indicating that nectar samples should be obtained at intervals during a plant's blooming period if the average reading is to be representative.—5-25-44.

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Cotton Nectar in Relation to Bee Activity and Honey Production

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Cotton is considered a good honey plant in many parts of the South but in California it has frequently failed to yield a crop of honey even though it is grown on large, concentrated acreages. To learn the reason for this failure a study was undertaken of the nectar-secreting capacity of the cotton plant in its relation to bee activity.

In the cotton flower the nectar glands are multicellular hairs packed close together to form a cushion on the inside surface of the base of the united sepals. The nectar collects in the cup thus formed by the sepals. The five separated petals overlap at their bases, forming small openings into the nectar cup. The blossoms secrete nectar during only part of one day, and in this respect cotton is radically different from some other plants. Nectar secretion proceeds normally in a mature bud when severed from the plant.

On account of the small opening between the petals, most insects cannot enter to secure nectar until after the petals wither, during the afternoon of the day a blossom opens. Honeybees, although provided with relatively long tongues, cannot secure nectar readily until withering begins or until the nectar droplets coalesce to fill the cup at the base of the flower. Since the blossoms usually do not open until 2 or 3 hours after sunrise, and they secrete no nectar until much later, the major part of the nectar comes into the hives after noon.

An experimental field of Acala cotton at Davis, Calif., in 1939 made a very satisfactory growth and set of blossoms and bolls, but only an occasional honeybee was found on the blossoms over a 15-week period. Scout bees were observed sampling the nectar, but none became loaded, nor was pollen collected. Bees located at the cotton field during blossoming time stored a surplus of both honey and pollen from yellow star-thistle.

Two kinds of cotton, Acala and Pima, were grown at Davis in a greenhouse[2] during the winter of 1940–41, and these and a third variety, SXP, from Arizona, were grown in 1941–42. Outdoor plots of the same kinds were grown at Davis and Winters in the following summers. A striking difference between varieties was noted in the blossoming habit and in the production of floral nectar. Pima invariably surpassed the others in the length of the blossoming period, in the daily number of blossoms, and in the amount of nectar per blossom. Acala produced the next largest number of blooms, whereas the SXP had only an occasional blossom, so few as to be considered nearly worthless from the standpoint of honey production. Little difference was noted in the sugar concentration of the floral nectars, which averaged close to 25 per cent in each variety. However, in several instances the Acala nectar contained slightly more sugar than the Pima.

One set of data, a composite one from Davis and Winters, is presented to illustrate the extreme difference in the quantity of nectar per blossom. On August 25, 1942, each Acala blossom had from 0 to 8 microliters of nectar, SXP about 12, and Pima from 30 to 50. The respective sugar concentrations of the nectars were 33.9, 23.9, and 25.9 per cent. The average numbers of blossoms per plant on August 31 were as follows: Acala 0.75, SXP 0, and Pima 2.23. On the basis of these data 1 acre of Pima cotton is the equivalent of at least 30 acres of Acala from the viewpoint of honey production. Formerly, when short staple and Pima cotton were grown in the Imperial Valley, Pima was reported to be the source of the cotton honey during the late summer after alfalfa had practically ceased to yield.

Cotton also produces extrafloral nectar to some extent. Each Acala and SXP blossom bract possesses a large gland, but the Pima often lacks it. The bract glands secrete over a long period during the growth of the boll. The few samples of bract nectar obtained under greenhouse conditions had a higher sugar content than the blossom nectar. For example, when floral nectar contained a little over

[1] In cooperation with the University of California.

[2] The greenhouse plants were grown by Robert Nash, of the University of California.

20 per cent of sugar, the bract nectar approached 40 per cent. In Arizona a little extrafloral nectar of about 50 per cent sugar was obtained from bees caught while visiting these glands, while the average for floral nectar at the time was about 25 per cent. Measurements on the production of extrafloral nectar in the field at Davis were not satisfactory, since the Argentine ant carried away the trace of such nectar as was secreted. Allard (1910) reported that in Georgia the honeybees during some periods visited the outer involucre nectaries almost to exclusion and at other times worked only the nectaries inside the blossoms.

Tiny leaf glands are also found on one to three of the midribs on the under surface of each leaf. The amount of secretion observed either in the greenhouse or out of doors has been negligible, with one exception. This instance was inside of an insect-proof glass case with the humidity near the saturation point. In such an atmosphere a small sample of leaf-gland nectar was procured which had a sugar concentration of 11.9 per cent. Bees have not been observed to visit glands on the leaf, and presumably they are of little importance as a source of supply to bees.

Cotton blossoms contain an abundance of pollen, but it was not observed to be deliberately collected to any extent by honeybees. The pollen grain is large and covered with beads of viscid material, which sticks the grains together to such an extent that the bee appears unable to place them in the corbiculae for transfer to the hive. While visiting cotton blossoms, the bee's body becomes plastered with the sticky pollen. It is apparently cleaned well within the hive, however, for upon reissuing from a hive on a cotton flow the bee is free of pollen, and in many cases almost hairless as well. The pollen thus gleaned is probably fed to the brood the same as pollens carried in the usual way. No cotton-pollen grains were found in the pollen reserves of bees working on cotton.

Nectars from different plants are known to vary in color, flavor, pH value, and the proportion of sugars and volatile oils. For example, cotton nectar is low in sucrose, while orange nectar contains a high percentage of this sugar. Analytical data for the sugars in these two nectars are shown in table 1. Cotton nectar is flavorless and odorless, but orange nectar has a pronounced flavor and aroma. Both are colorless. It seems logical to presume that bee activity is influenced by the aroma and the pH of nectars, as well as by their sugar constituents and concentration.

Table 1.—Sugars and moisture content of cotton and orange nectars.[1]

Plant	Levulose	Dextrose	Total Invert Sugars	Sucrose	Total Sugars	Approximate Moisture
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Cotton:						
Acala....	14.27	13.06	27.33	0.71	28.04	70
Pima....	10.36	9.25	19.61	0.35	19.96	80
Orange:						
Navel...	6.46	5.42	11.88	12.87	24.75	75
Valencia.	6.08	5.06	11.14	12.38	23.20	77

[1] Analyses made by H. W. Allinger, of the University of California at Davis, using the methods of the Association of Official Agricultural Chemists.

In California the commercial production of cotton covers an area of about 361,000 acres in the upper San Joaquin Valley, and the Acala variety is grown exclusively. The Acala blossoms in this area produce nectar, for it was possible to collect liberal samples in pipettes. The variability in cotton-honey yields there is strongly influenced by the presence of other nectar plants upon which for various reasons bee activity is more intense. For example, wherever cotton blossoms, with their nectar averaging 25 to 30 per cent of sugar, must compete with alfalfa, which has nectar of much higher sugar concentration (41 per cent) the honey store is likely to be mostly from alfalfa. On the other hand, where bluecurls is the competitor, with its nectar averaging around 27 per cent of sugar, bees are more likely to store both nectars together, producing a blend of honey. Where cotton is about the only source, bees store this honey freely to give a typical cotton honey. Therefore, cotton-honey production in the vicinity of McFarland, where there are comparatively few other plants to compete with cotton, is more certain than in many other parts of the Valley.

SUMMARY.—Comparative studies of nectar secretion by Pima, Acala, and SXP cotton have shown that the Pima far surpasses the others in the quantity of floral nectar produced. Very little extrafloral nectar was in evidence. Cotton floral nectar was low in sucrose, while in orange

nectar about 50 per cent of the total sugar was sucrose. Bee activity in the collection of nectar from Acala cotton, which is grown exclusively in the San Joaquin Valley of California, is influenced adversely by the presence of other plants, particularly alfalfa, with richer nectars. Cotton produces an abundance of pollen, but the bees did not collect it except by gleaning the clinging grains from the nectar-gathering bees which entered the hive. —1-28-44.

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Some Western Nectars and Their Corresponding Honeys

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It has long been known that honeys differ considerably in both physical characteristics and chemical composition. Browne (1908) analyzed 92 samples of floral honey from various parts of the United States, and more recently Eckert & Allinger (1939) reported data for 106 samples of California floral honey. It may therefore be assumed that the nectars of different flowers also vary in composition. Caillas (1926) and Beutler (1930) have shown this to be true for the flowers that they studied, particularly with respect to the moisture and sugar content. Vansell & Freeborn (1929) reported the pollen content of six kinds of honey to range from 3000 to 599,000 grains per milliliter, and Todd & Vansell (1942) found from none to 111,000 grains per milliliter in hand-collected nectar.

There is a difference of opinion as to how the bees convert the nectar of flowers into honey, but it is generally conceded that the principal changes consist in reduction of the water content and conversion of the sucrose to invert sugars. Invertase for the conversion process is present in pollen (Paton 1921) and in the various parts of the bee's body (Phillips 1927), and some workers credit the bee with adding invertase to the nectar. The surplus moisture is removed by ventilation of the hive. Park (1927) has shown that when thin sugar sirup is placed in the hive, although separated by screen from the bees, it loses water and becomes of honeylike consistency within three days.

This paper presents data on the nectars of orange, cotton, and eucalyptus blossoms, and on honeydew from incense cedar, in comparison with data previously reported for the corresponding honeys. Data on vetch honey and poinsettia and waxplant nectar are also included. The average percentage composition of honeys as given by Browne (1908) and by Eckert & Allinger (1939) is shown in table 1.

EXPERIMENTAL METHODS.—Most of the nectar samples were collected directly from the blossoms by means of pipettes, but some were taken from the nectar sacs of bees. The nectar was placed in vials and preserved with toluene. The vials of orange, cotton, and eucalyptus nectars were sent by air mail to the laboratory for speedy analysis.[2] Some aliquots of orange nectar were also stored at 36° F. for one year before being analyzed. However, other samples held at this temperature were found to be practically unchanged. Poinsettia and waxplant nectars were collected from greenhouse plants and were analyzed immediately. The cedar honeydew was taken from the excretion tubes of the scale insects that produced it. All the nectar samples originated in California.

The methods for the nectar analyses were the same as those used by Eckert & Allinger (1939) in their honey investigations, except that the levulose and dextrose were determined by the Lothrop-Holmes (1931) method.

Extracted honey is somewhat mixed as to source, because frequently there is more than one honey in a single comb,

[1] In cooperation with the University of California, College of Agriculture.

[2] The chemical analyses were made by H. W. Allinger, of the Chemistry Division of the University of California College of Agriculture at Davis.

Table 1.—Average percentage composition of honeys as reported by Browne (1908) and Eckert & Allinger (1939).

COMPONENT	BROWNE, HONEYS FROM VARIOUS PARTS OF U. S.	ECKERT & ALLINGER, CALIFORNIA HONEYS
Levulose	40.50	40.41
Dextrose	34.02	34.54
Total invert sugar[1]	74.98	74.95
Sucrose	1.90	2.53
Total sugars	76.88	77.48
Acid, as formic	.08	.16
Ash	.18	.21
Moisture	17.70	16.50
Dextrin	1.51	0.91
Undetermined	3.73	4.72

[1] The average levulose-dextrose (L/D) ratio is 1.19 for the honeys reported by Browne and 1.17 for those analyzed by Eckert and Allinger.

and during extraction all the cells are uncapped for emptying the comb. Some unavoidable discrepancies therefore occur in a comparison of a nectar with the commercial honey.

COMPARISON OF NECTARS AND THE CORRESPONDING HONEYS.—The analytical data for nectars and honey from orange, cotton, eucalyptus, and vetch and for cedar honeydew and honey are given in table 2.

The nectars from both navel and Valencia orange blossoms were colorless, with a pronounced aroma of orange blossoms, and of similar composition. They differed chiefly in pollen content, for navel-orange nectar contained no pollen while the Valencia nectar had about 2400 grains per milliliter. Since the ash content was about the same, it appears to be a constituent of the nectar itself and not of the pollen. The sucrose content was high, comprising more than half the total sugars. A comparison of orange honey with these nectars shows that two-thirds of the sucrose was inverted by the bees, but the levulose-dextrose ratio (L/D) was not changed. The other data are fully accounted for by the reduction of moisture. Orange honey, like orange nectar, is colorless and has a high sucrose content well above average for California honey samples (Table 1).

The cotton nectars were colorless and odorless, contained no pollen, and were similar in composition except for a 10-per cent greater water content and less acidity (higher pH) in the Pima variety. Cotton nectar had a very low sucrose content. In cotton honey all changes in constituents except the ash were accounted for by the evaporation of water. The L/D ratio indicates almost equal amounts of dextrose and levulose, which is probably the reason for its rapid crystallization. It is known, for example, that sage honey, with an L/D ratio of 1.35, does not readily crystallize.

The source of ash in some cotton honey is difficult to explain. In three samples of variously colored cotton honey from the southern states Browne (1908) found 0.13, 0.14, and 0.38 per cent of ash. The second sample was most typical of cotton honey in that it was colorless while the others were darker. Fraps (1921) found 0.32 per cent and Lothrop (1940) reported 0.43 per

Table 2.—Percentage composition of various nectars and the corresponding honeys.[1]

SAMPLE	LEVULOSE	DEXTROSE	TOTAL INVERT SUGARS	LEVULOSE-DEXTROSE RATIO (L/D)	SUCROSE	TOTAL SUGARS	pH VALUE	ACID	ASH	APPROX. MOISTURE	APPROX. RATIO TOTAL SUGARS TO WATER
	Per cent	*Per cent*	*Per cent*		*Per cent*	*Per cent*		*Per cent*	*Per cent*	*Per cent*	
Orange:											
Navel nectar	6.46	5.42	11.88	1.18	12.87	24.75	3.8	0.02	0.023	75	0.33
Valencia nectar	6.08	5.06	11.14	1.20	12.38	23.52	4.35	.018	0.22	77	.32
Honey	40.86	34.23	74.37	1.19	4.13	78.50	—	.12	.08	16	4.95
Cotton:											
Acala nectar	14.27	13.06	27.33	1.09	0.71	28.04	3.5	—	.06	70	.40
Pima nectar	10.36	9.25	19.61	1.12	0.35	19.96	5.7	—	.05	80	.25
Honey	41.80	37.60	79.40	1.11	1.11	80.51	—	.19	.49	15	5.37
Eucalyptus:											
Nectar	5.47	5.23	10.70	1.04	5.78	16.48	—	—	—	84	.20
Honey	40.85	34.53	75.38	1.18	.87	76.25	—	.15	.22	19	4.01
Incense cedar honeydew:											
Sample 1	—	—	23.75	—	12.55	36.30	—	—	—	—	—
Sample 2	—	—	—	—	—	33.00	—	—	.54	—	—
Honey	36.4	27.1	63.6	1.34	4.29	67.92	—	.25	.78	15	4.52
Vetch honey	40.65	34.15	74.80	1.16	1.19	75.99	—	—	.40	16	4.75

[1] All honey analyses except vetch from data given by Eckert and Allinger (1939); analyses of vetch honey by Allinger.

cent of ash in cotton honey. In cotton honey from California Eckert and Allinger (1939) found on an average 0.49 per cent of ash. The Acala and Pima nectars reported in table 2 should, theoretically, yield honeys with about 0.26 and 0.25 per cent of ash, respectively. Nectar taken from the honey stomachs of bees collecting from the extrafloral nectaries of cotton contained 0.1 per cent of ash, twice that obtained by hand-collected samples from blossom nectaries. It appears, therefore, that the large amount of ash in some cotton honey must come from an extraneous source such as dust.

The nectar collected from eucalyptus, *Eucalyptus globulus*, or blue gum was colorless, had a pronounced odor, and contained a small amount of pollen. Dextrose, levulose, and sucrose were present in about equal amounts. The total sugars in this honey could be accounted for by the evaporation of moisture. Nearly all the sucrose in the nectar had been inverted, but the L/D ratio differs sufficiently to indicate either a different source or a mixture of sources. The honey sample was of uncertain origin; it may have been from more than one species of eucalyptus.

The samples of vetch nectar were colorless and without detectable odor, and the hand-collected nectar contained no pollen. Chemical analyses were not made, but according to Wilson (1878) a vetch, *Vicia cracca*, raceme contained 3.15 milligrams of invert sugars and 0.01 milligram of sucrose. The percentages of these sugars in Oregon vetch honey were 74.80 and 1.19 Vetch honey in Oregon is usually a vetch-alsike clover mixture.

Honeydew obtained from incense cedar, *Libocedrus decurrens*, is colorless when first given off by the scale insect *Xylococculus macrocarpae* Coleman, but becomes light amber after it has remained for a time on the bark of the tree. This honeydew contained an unusually high percentage of dextrin (average 10.3). On the basis of 33 per cent of total solids in one field sample, as determined by the refractometer, and 16 per cent of moisture, the honey would be expected to have about 2.2 per cent of ash. The ash value for four samples of the honey averaged 0.78, but the range was 0.60 to 1.11 per cent. No pollen was observed in the hand-collected honeydew. The few pollen grains found in this honey are not from cedar but from miscellaneous flowers and grasses. That this honeydew is usually mixed with floral nectar is further indicated by the great variation in the color of the honey.

EFFECT OF STORAGE ON POINSETTIA AND WAXPLANT NECTARS.—Fresh poinsettia, *Euphorbia pulcherrima*, nectar was colorless and odorless, and contained almost no pollen. On the basis of the ash content of its nectar, poinsettia honey should have about 0.25 per cent of ash, but honey from this source is not reported in this country. One sample of hand-collected poinsettia nectar, after being kept for a long period in the laboratory, lost water to become as thick as honey, became light amber in color, and most of the sucrose was changed to invert sugars. This virtually was a honey produced without contact with the bee.

The nectar from waxplant, *Hoya carnosa*, was colorless and odorless, and contained no pollen. One sample was analyzed 25 days after collection, whereas the other was kept in storage for a year. The higher invert-sugar content of the second sample indicates that inversion of sucrose occurred on standing. Planta (1886) reported only 4.99 per cent of reducing (invert) sugars and 35.65 per cent of sucrose in the fresh nectar.

Table 3 gives data on these nectars.

Table 3.—Percentage composition of fresh and stored poinsettia and waxplant nectars.

Nectar	Levulose	Dextrose	Total Invert Sugars	Levulose Dextrose Ratio (L/D)	Sucrose	Total Sugars	pH Value	Acid	Ash	Approx. Moisture	Approx. Ratio Total Sugars to Water
	Per cent	*Per cent*	*Per cent*		*Per cent*	*Per cent*		*Per cent*	*Per cent*	*Per cent*	
Poinsettia:											
Fresh	—	—	31.28	—	17.19	48.47	3.2	.191	.081	51	.95
Stored	17.48	21.01	38.49	.83	9.69	48.18	—	—	—	50	.96
Waxplant:											
Fresh	—	—	11.9	—	28.9	40.8	—	—	—	60	.68
Stored	—	—	20.9	—	8.3	29.2	—	—	—	70	.42

ASH CONTENT OF HONEYS.—Judging from the data on the ash values of blossom nectars, a floral honey should have a low ash content unless a very large amount of pollen or other ash-carrying constituents becomes incorporated in it. A honeydew honey, however, should have considerable ash even though it contains no pollen. Bees knock pollen into the nectar when visiting perfect flowers, and microscopical examination of nectars has shown the pollen grains to be from the same plant as the nectar. When nectar is carried in the honey stomach, the number of pollen grains is reduced by the action of the honey stopper (proventriculus), but their water-soluble constituents may still remain in the nectar.

Todd & Bretherick (1942) found the average ash content of 33 pollens to be 2.70 per cent. The maximum number of pollen grains found in nectar, 111,000 per milliliter (Todd Vansell 1942), would account for about 0.006 per cent of its ash content. The addition of 1 gram of pollen pellets to 1 liter of sugar sirup resulted in the presence of 43,800 pollen grains to each milliliter. Manifestly a very large number of pollen grains is required to have a significant affect on the ash content of a nectar or honey.

SUMMARY.—The honeybee confines its visits to one kind of blossom in the collection of nectar, since a hand-collected nectar has characteristics similar to a honey made during the blossoming period of that plant.

Nectars of different plants vary in odor, acidity, and content of sugars and ash, as well as in the water and pollen content. Cotton nectar was practically devoid of sucrose. The sucrose present in poinsettia nectar slowly changed to invert sugars without invertase being supplied by the bee. The ash values of both pollenless and pollen-carrying orange nectars were in line with that of the orange honey, but in some samples of cotton honey the ash value was disproportionately high. The ash values of both honeydew and the resulting honey were higher than those of nectar or honey from floral sources.—3-20-44.

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HAEUSSLER HEADS INSECT PEST SURVEY

Dr. Gilbert J. Haeussler, of the Division of Fruit Investigations in the Bureau of Entomology and Plant Quarantine, has been appointed chief of the Division of Insect Pest Survey and Information, Dr. Haeussler takes the place made vacant by the voluntary retirement of Dr. James A. Hyslop who built up the survey to a high state of effectiveness before its activities were somewhat curtailed as a result of war conditions.

Control of the Pickleworm on Squash and Cucumber

OTELIA F. BODENSTEIN, *Virginia Agricultural Experiment Station, Blacksburg*

Reid & Bare (1935) conducted experiments on the control of the pickleworm, *Diaphania nitidalis* (Stoll), on squash, cucumber and cantaloupe and found that 1 per cent rotenone was more toxic than 0.5 per cent rotenone or 50 per cent calcium arsenate. The 0.5 per cent rotenone dust was approximately as toxic as the calcium arsenate mixture. Fulton (1936) dusted squash at weekly intervals with a 1 per cent rotenone dust and the infestation in the dusted plots was 36 per cent as compared with 70 per cent in the check plot; and in later experiments, he (1937) found that lead arsenate and cryolite were superior to rotenone for the control of the pickleworm. Watts (1939) reported that weekly applications of 0.75 per cent rotenone dust (from cubé root) and 10 per cent calcium arsenate dust were ineffective on late cucumbers and cantaloupes. Arant (1940, 1941, 1942) found a derris-talc dust containing 1 per cent rotenone to be effective in controlling the pickleworm when applied at 5-day intervals. Clayton (1942) reports satisfactory control with cryolite dust applied at 5- to 7-day intervals. Applications at 10- to 14-day intervals did not give satisfactory control. Floyd *et al.*, (1942) got considerable reduction in pickleworm injury on cucumber and squash with cryolite mixed with copper and nicotine.

During the summer of 1943 the writer conducted experiments on squash and cucumber to determine the toxicity to the pickleworm of various insecticides obtainable under wartime conditions.

MATERIALS AND METHODS.—Tests were made with the following materials: natural cryolite, rotenone, lead arsenate as a dust, lead arsenate as a spray, and lead arsenate and oil as a spray.

The cryolite, obtained under the trade name *Kryocide*, contained not less than 90 per cent of sodium fluoaluminate and was used as a dust prepared from 1 part of *Kryocide* and 2 parts of talc. The rotenone dust was the proprietary preparation *Agicide*, which contained 0.12 per cent of rotenone and 0.32 per cent of derris resins (less rotenone). The lead arsenate was standard lead arsenate of the *Nu Rex-form* brand. As a dust, it was diluted 1 part to 4 parts with hydrated lime; and as a spray, it was used at the rate of 4 pounds per 100 gallons of water, both when used alone and when used with the oil. The oil used in the lead arsenate-oil spray was *Orthol-K*, diluted to give 0.415 per cent actual oil.

Applications were made on both the squash and the cucumber on June 5 and June 8. A hard shower followed closely after each treatment. Because of the large number of striped cucumber beetles present on the young plants and the frequent showers, the cucumber plots were treated on June 10, 12, 15 and 18. All plots, except checks, were treated at 6- to 8-day intervals from July 1 through August 16; and all plots, including the checks, were dusted once, June 10, with a fungicide composed of tribasic copper sulphate 13 per cent, soybean flour 10 per cent, and talc 77 per cent.

The dusts were applied with a hand-power blower duster, and the sprays with a 4-gallon compressed air sprayer.

The first squashes were picked at market size on July 6; and pickings were made at 2- to 3-day intervals thereafter throughout the season, the last picking being made on August 23. The first cucumbers were picked on July 5, and pickings thereafter were made at the same time as the squash pickings, the last picking also being made on August 23, at which time practically all the vines were dead. Fruit from each plot was kept separately and was counted, weighed and examined. A fruit in which a worm was found or one in which a tunnel appeared, was considered wormy.

EXPERIMENTAL DESIGN.[1]—An area 175 by 70 feet was planted in squash and cucumber, 125 by 70 feet being used for the squash and 50 by 70 feet for the cucumber. *Golden Summer Crookneck* squash was planted on May 22 in hills 3 feet apart and in rows 5 feet apart. The test area consisted of five randomized blocks each with six plots. The position of the plots within the blocks was left to chance, ex-

[1] The experiments were planned and conducted by E. H. Glass until July 1 when they were taken over by the writer.

cept that a treatment was not allowed to occur in such a way that it fell in line with itself in the field. The plots consisted of two rows with eight hills each. The plants were thinned to three per hill.

A pickling variety of cucumber was planted on May 14. The same arrangement of plots was used as with the squash but each plot consisted of only four hills, two to a row and 5 feet apart.

RESULTS AND DISCUSSION.—Table 1 shows the percentages of wormy fruits in the variously treated squash plots at each picking. The infestation was light, even in the check plots, at first but increased as the season advanced. Approximately half of the fruits were picked before an infestation as great as 5 per cent was found. Except on August 13, when 5.71 per cent of the fruits were wormy, the infestation in the cryolite-treated plots remained below 3 per cent until the last picking, when it jumped to 14.29 per cent.

Table 2 gives the results of the experiments with the squash. Although there seems to be quite a difference between the total yield in the variously treated plots, as shown in the table, an analysis shows no significant difference in the weight or number. There was a wide variation in the yield in the different rows in the field. Owing to the frequent rains early in the season, several rows on one side were not weeded until late, and consequently the vines in these rows were less vigorous and the yield was reduced. Some of the treatments occurred more times in these rows than other treatments and, therefore, had a lower total yield in comparison than would otherwise have been the case. If the weeding had been done block by block a better comparison of the yield could have been made.

An analysis of variance of equivalent angles of the percentages of wormy squashes is shown in table 3. There was no difference between the results obtained in the plots treated with lead arsenate spray and lead arsenate and oil spray. The lead arsenate dust was not significantly better than the rotenone dust. There was a highly significant difference between the cryolite dust and the average of the lead arsenate and rotenone dusts. The cryolite gave a much better control. Neither of the sprays gave any better results than was obtained in the check plots. A comparison of the three dusts with the two sprays and

Table 1.—Percentage of wormy squashes per treatment for each picking and total number of squashes picked.

Date	Cryolite Dust	Rotenone Dust	Lead Arsenate Dust	Lead Arsenate Spray	Lead Arsenate and Oil Spray	Check	Total Number Fruits
			Per Cent				
July 6	0.00	0.00	0.00	0.00	0.00	0.00	35
9	0.00	0.00	0.00	0.00	0.00	0.00	179
12	0.00	4.54	0.00	0.00	0.00	0.00	255
15	0.86	0.00	0.00	1.06	0.00	1.39	581
17	0.00	1.55	0.88	0.89	0.90	0.88	703
19	0.88	0.91	1.19	1.35	0.00	0.00	581
21	1.15	4.84	0.00	0.00	0.00	0.00	472
23	0.00	1.37	0.00	0.00	1.05	1.24	512
26	0.79	0.86	2.08	1.03	0.00	2.78	670
28	0.00	3.23	2.78	7.90	0.00	6.67	221
30	0.00	0.00	0.00	1.96	1.59	3.12	277
Aug. 2	1.98	1.45	1.30	2.50	11.02	3.45	532
4	1.09	3.85	0.00	8.70	5.13	2.86	465
6	1.11	4.69	7.35	9.86	12.66	16.18	440
9	2.25	4.41	8.11	18.18	19.05	20.13	445
11	0.00	24.59	3.08	18.75	31.92	35.71	318
13	5.71	16.07	14.75	37.21	41.67	40.98	375
16	2.78	20.00	14.58	54.84	43.24	54.29	207
18	2.94	39.66	39.39	60.34	59.02	58.54	352
20	2.56	56.25	37.50	42.31	60.00	57.69	172
23	14.29	52.94	56.00	83.33	66.67	54.54	138
Average	1.63	7.32	6.62	11.30	12.21	12.36	7930

the untreated plots showed a highly significant difference. Any of the dusts used produced more worm-free fruit than was

Table 2.—Results of experiment on the control of the pickleworm on squash for the entire season.

	Number Wormy	Per Cent Wormy	Number Squash	Weight Squash
				Pounds
Cryolite dust	25	1.63	1531	580
Rotenone dust	90	7.32	1229	414
Arsenate of lead dust	90	6.62	1359	487
Arsenate of lead spray	138	11.30	1221	424
Arsenate of lead and oil spray	175	12.21	1433	480
Check	143	12.36	1157	384

was found in the check or in the sprayed plots.

The infestation of the cucumbers was so light that the data are not tabulated in this paper. Of 3706 cucumbers picked during the season, only 27 cucumbers, or 0.75 per cent, were wormy. The wormy fruits were found in various plots but nowhere occurred in numbers sufficient to judge the merits of the treatments used. The squash, being a preferred food plant of the pickleworm, had acted as a trap crop and protected the cucumbers.

SUMMARY AND CONCLUSIONS.—Three dusts, cryolite, rotenone and lead arsenate, and two sprays, lead arsenate alone and lead arsenate with oil, were applied to squash and cucumber.

Of the materials tested on the squash, cryolite gave a significantly better control of the pickleworm. The rotenone dust and lead arsenate dust gave some control but the sprays gave none. The percentage of wormy fruits found on each plot was as follows: cryolite dust, 1.63 per cent; rotenone dust, 7.32 per cent; lead arsenate dust, 6.62 per cent; lead arsenate spray, 11.30 per cent; and lead arsenate and oil spray, 12.21 per cent. The untreated plots had an infestation of 12.36 per cent.

Table 3.—Analysis of variance of angles corresponding to percentages of wormy squash in field experiment for the pickleworm.[1]

Source of Variation	Degrees of Freedom	Mean Square
Treatment	5	[2]125.21**
Lead arsenate spray *vs.* lead arsenate and oil spray	1	.60025
Rotenone dust *vs.* lead arsenate dust	1	.12996
Cryolite dust *vs.* average of rotenone and lead arsenate dusts	1	202.754**
Check *vs.* average of lead arsenate sprays	1	.0083
Dusts (lead arsenate, cryolite and rotenone) *vs.* sprays (lead arsenate and lead arsenate and oil) and check	1	422.025**
Block	4	4.872
Experimental error	20	5.6377

[1] Acknowledgment is due Boyd Harshbarger, Statistician, under whose direction the analysis was made.

[2] A double asterisk indicates a significant difference passing the 1 per cent standard, between the treatment groups indicated.

Weekly applications of cryolite dust kept the pickleworm infestation below a 3 per cent level through the August 20 picking except on August 13, when it reached 5.71 per cent. Fruits picked from the check plots on July 28 were 6.67 per cent wormy. The cryolite dust substantially increased the number of saleable fruits, and it appears that with the application of cryolite dust a grower of summer squash can extend the harvest of substantially worm-free squash for several weeks.

Cucumbers grown in a plot adjoining squash were practically free from pickleworm injury.—3-27-44.

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SCIENTIFIC NOTES

DDT as a Contact Poison for Honeybees

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and
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A recent report by Holst (1944) concerning stomach and contact action of DDT to honeybees leaves one with the impression that rather long exposures and high concentrations of DDT are required to kill honeybees. Recent laboratory experiments by the authors where the contact action of DDT was tested by exposing honeybees to glass plates containing a dry spray film of DDT showed that 20 to 30 minute exposures resulted in a high kill of honeybees within 12 hours. Spray suspensions containing 1 pound of DDT to the 100 gallons or 0.125 per cent DDT were used in these tests. This concentration is only slightly more than twice the 0.05 per cent DDT concentration which Holst (1944) reported as exhibiting no contact poisoning effect, and is one-eighth of the 1 per cent DDT concentration which was found to be effective. A measure of the spray deposits obtained on the glass plates determined by air drying the plates to a constant weight before and after spraying showed that the deposits varied from 0.00001 to 0.00041 grams of DDT per square inch. In our tests with a 30 minute exposure period the lowest deposit was sufficient to give approximately 100 per cent mortality to honeybees.

Preliminary tests in which 40 to 50 honeybees were confined in open bottomed screen wire cages over glass plates sprayed with 0.125 per cent DDT showed that approximately all the bees were killed in a 12 hour period. In later tests the caged bees were exposed to the sprayed plates for periods varying from 10 to 80 minutes and compared with cages of untreated bees for periods of 3 or 4 days. A series of these time interval tests showed that exposures of 30 minutes or more resulted in approximately 100 per cent mortality of the bees in a period of 12 hours. Exposure periods of 15 minutes or less rarely showed any greater mortality than the check cages, while a series of 20 minute exposures resulted in approximately 60 per cent mortality of honeybees. A later series of tests in which the caged bees were exposed to the sprayed plates for 5 and 10 minute periods at intervals of one hour resulted in 100 per cent mortality to the bees within 12 hours whenever the total exposure time exceeded 30 minutes.

The screen wire cage method of testing probably does not give an exact measure of the contact action of DDT to honeybees because the bees spent part of their time on the unsprayed screen wire. Attempts to improve the method by depositing the spray film on the inner surfaces of glass tubes so that the bees would be constantly in contact with the spray deposit has not greatly changed our results at the present time. This might be expected as the lowest spray deposit proved as effective as the heaviest deposit in our screen wire cage tests.

Observations during these experiments show that the paralytic action to honeybees often is apparent after a few minutes exposure to the DDT sprayed plates. The first symptoms are concerned with the loss of control of the legs, followed by paralysis of the hind legs and finally the rolling falling action which Holst (1944) states occurs several hours after bees have been fed DDT. In our tests death did not always occur following this paralytic action.

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Field Tests of DDT to Control the Peachtree Borer

BYRLEY F. DRIGGERS, *New Jersey Agricultural Experiment Station*, and CHARLES L. SMITH, *Rutgers University, New Brunswick*

Fleming & Chisholm (1944) have reported the effect of DDT on Japanese beetle, *Popillia japonica* Newm., in field tests on peaches. Driggers (1944) published data on the control of the Oriental fruit moth, *Grapholitha molesta* Busck, from the same set of plots. This paper sets forth data from these plots showing a residual effect of DDT in the control of the peachtree borer, *Aegeria exitiosa* Say.

Two single row plots running across several varieties of five-year-old peach trees were sprayed with a mixture of DDT, calcite and fish glue at the rate of 1 pound of DDT to 100 gallons of water. The treatment was applied July 14, 1943. The spray was directed at the foliage and fruit, no effort being made to spray the trunk and crotches or the ground around the trunk of the trees.

In the fall of 1943 it occurred to the writers that the residue of DDT weathering from the foliage to the larger limbs, crotches and trunks of the peach trees may have some effect in controlling the peachtree borer. When the block of trees were treated with ethylene dichloride emulsion in the fall of 1943 to control the peachtree borer the two rows of trees sprayed with DDT on July 14 were left untreated. In addition, check rows on each side of the DDT sprayed rows were left untreated with ethylene dichloride.

April 28 to 30, 1944 the DDT sprayed trees and the unsprayed "check" trees were examined carefully for borers. On 10 of the 12 trees sprayed with DDT no borers were found; on the two remaining trees 9 live borers were recovered on one tree and one on the other tree. Of the 24 "check" trees examined, 23 yielded live borers ranging from 1 to 16 per tree with an average of 6 live borers per tree. In addition 5 dead borers were found on the 24 "check" trees. The 10 live borers found in the two DDT sprayed trees were all from one-half to two-thirds grown on April 28, 1944. Their size indicated they may have entered the trees previous to July 14 when the DDT was applied.—5-15-44.

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Toxicity of DDT to *Macrocentrus ancylivorus* Rohwer

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Preliminary laboratory and field tests (Carman & Fleschner 1944; Driggers 1944) have shown that dichlorodiphenyl-trichloroethane (DDT) is very toxic to the larvae of the Oriental fruit moth. The important role played by parasites, particularly *Macrocentrus ancylivorus*, in holding this insect in check is generally recognized. The effect of DDT on these parasites which are being reared in large numbers for mass liberation in peach orchards, immediately became a question of paramount importance. The high mortality of fruit moth larvae obtained from spraying with DDT might be offset, at least partially, by its adverse effects on the natural enemies of the fruit moth.

These considerations led the writers to tests in the laboratory with DDT to determine its effects on adults of *Macrocentrus ancylivorus*. Several hundred recently emerged adults of the parasites were obtained from the laboratories of the New Jersey State Department of Agriculture at Trenton. The caged parasites were refrigerated at 40° F. until ready for use (24 hours).

Dome-shaped cages 3.5 inches high and 5 inches in diameter were sprayed with DDT at a dilution of 1 pound in 100 gallons of water. The cages were allowed to dry thoroughly and 20 to 25 *Macrocentrus ancylivorus* adults (40 per cent females, 60 per cent males) were introduced into the cages. The insects were supplied water by means of a vial fitted in the top of the cage and fed with a drop of honey placed on a card beneath the cage. Exposure for 12 hours resulted in 100 per cent mortality. Unsprayed cages were used as checks and no mortality occurred.

Another test was conducted when the cages were not sprayed but instead 20 to 25 *Macrocentrus ancylivorus* adults were introduced into clean cages and the cages set on glass plates which had previously been sprayed with DDT (1 pound to 100 gallons) and allowed to dry. The insects were fed and watered as described above. In this case the kills obtained were not complete since apparently the habit of the insect caused it to spend most of its time on the wire. 70 per cent kill was recorded at the end of 12 hours and 80 per cent kill at the end of 36 hours.

Further tests were made in which glass tubes 1.5 inches in diameter and 9 inches long were sprayed on the inner surface with DDT at the rate of 1 pound to 100 gallons of water. Twenty to twenty-five *M. ancylivorus* adults were introduced into the tubes and allowed to remain for 15 and 30 minute periods, and then removed to clean cages, fed and watered in the manner described above. These short exposures to a dry film of DDT caused severe paralysis and nervous response, but mortality after 12 hours was only 4 per cent for the 15-minute exposure and 15 per cent for the 30-minute exposure. After 36 hours the mortality had increased to 26 per cent and 42 per cent respectively.

These tests show that short exposures of 30 minutes or less to surfaces sprayed with DDT are not sufficient to give complete kills. However, 12 hours exposure to a sprayed surface resulted in 100 per cent mortality. In view of the habits of these parasites such a contact with the material is very likely. These laboratory tests indicate, therefore, that thorough study of this problem in the field must be undertaken before DDT can be recommended as a proper material for control of Oriental fruit moth.—5-15-44.

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A Positive Feeding Device for Application of Dust Mixtures

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In conducting insecticide tests against the pea aphid on broadcast canning peas, one of the most difficult problems encountered is that of obtaining accurate rates of application with dust mixtures of varied composition. The mechanism described herein was developed to solve this problem.[2]

Experimental plots range from 0.16 to 0.25 acre in size. The dosage of materials ranges from 20 to 60 pounds per acre or from approximately 3 to 15 pounds per plot. With the power dusters employed on this project it has been necessary to keep a surplus of from 25 to 30 pounds of dust in the hopper all the time to prevent extreme variations in the rate of discharge which are likely to occur if the dust level gets below a certain point. Even when this precaution is observed, frequently there is too great a variation in the rate of application between the replicates of one treatment, as well as between different treatments, to permit accurate evaluation of results. Moreover, in order to obtain an accurate record of the quantity of dust used per plot it is necessary to remove and weigh the 25 or 30 pounds of excess dust in the hopper after each of the replicates has been treated. Such a task is both time-consuming and disagreeable to operators. On account of the time consumed it involves the risk of sudden changes in weather conditions which might throw out an entire experiment. With this new feeding device it is possible to complete a series of tests within a few hours and usually under uniform weather conditions.

The apparatus consists of a small V-shaped hopper made of steel, in the base of which is mounted a feeding screw made from a 1.25-inch wood bit. The shank of the screw extends through the inner end of the hopper and through a bronze bearing welded to the hopper. A step pulley is fastened to the end of the shank. A metal shoulder fitted to the shank just inside the hopper holds the screw in place. The point and lips of the screw are ground off flat, and this end of the screw, with very slight clearance, extends through a reinforced aperture in the other end of the hopper.

An agitator made by welding 1-inch lengths of

[1] In cooperation with the Wisconsin Agricultural Experiment Station.

[2] The hopper assembly of this device was made by Frank M. Wolf, Mechanician, of the College of Engineering, University of Wisconsin, and was copied from a piece of apparatus originated by him.

eighth-inch steel wire crosswise to a piece of eight-inch pipe is mounted above the screw so as just to clear it. Properly spaced holes in each end of the hopper serve as bearings for the agitator, one end of which extends through the hopper and, fitted with a 2-inch pulley, is driven from a 1-inch pulley on the counter-shaft by means of a round belt.

A small, light-weight gasoline motor—the kind often used on washing machines and lawn mowers—supplies the power. The motor itself is of variable speed and can be run between 1400 and 2200 r.p.m. In order to provide a greater range in the speed of the screw a counter-shaft is employed. A 2.5-inch pulley on the motor drives an 8-inch pulley on the counter-shaft by means of a V belt.

A set of four step pulleys—1.75″, 2.25″, 3″, and 3.75″—is mounted on the counter-shaft (Fig. 1). Connection by means of a V belt is made with a like set of pulleys mounted on the shank of the screw. The whole apparatus is mounted on a light framework of angle-iron, with a wooden platform provided for the motor. The motor is bolted to the wooden platform through slotted holes to provide for adjusting the drive belt when necessary.

The counter-shaft is pivoted and, being adjustable, serves as a belt tightener. It takes but a moment to loosen it when the belt is changed on the step pulleys.

FIG. 1.—Top view of positive feeding device showing (1) agitator inside hopper, (2) drive pulley on engine, (3) step pulley on counter-shaft, (4) step pulley on screw, and (5) agitator pulley and drive belt.

The entire apparatus, weighing only 79 pounds, is set on the hopper of a power duster and lightly fastened to it. A galvanized tube, 1.75 inches in diameter and fitted at the top with a wide-mouth funnel, extends from the mouth of the screw aperture down through the bottom of the hopper just into the air chamber.

When using the smallest pulley on the counter-shaft with the largest pulley on the screw and varying the motor speed through its range of 800 r.p.m. the speed of the screw can be varied to run between 150 and 240 r.p.m. This range will result in delivery of the average rotenone-bearing dust mixture at the rate of from 20 to 40 pounds per acre, while the duster (equipped with a 24-foot boom) is traveling through plots of peas at the rate of 2.5 miles per hour. When the next larger pulley on the counter-shaft is employed with the next smaller pulley on the screw, and use is made of the variable speed of the engine, the speed of the screw can be varied to run between 240 and 420 r.p.m. This range in speed will make it possible to apply dust mixtures at from 40 to 65 pounds per acre. The larger pulleys on the counter-shaft may be used when it is desired to apply larger dosages.

Before applying any dust in the field the feeding device is calibrated for each dust mixture to be employed. This is a simple job and is performed by passing a mixture through the device for exactly one minute, catching it in a paper bag at the mouth of the screw aperture (for this operation the tube and funnel are removed), weighing the quantity of dust delivered and, if necessary, making adjustments in speed and repeating the operation until the desired output is reached.

When preparing for operations in the field, dust mixtures are weighed into 10-, 12-, or 20-pound double paper bags with sufficient dust in each bag to treat a plot, plus a 5 per cent excess. The six bags of dust for each set of replicates are properly marked and placed together, usually in a greenhouse flat. Thus the supply of dust for many treatments can be carried on the truck on which the duster is mounted. In operation, the dust is slowly poured from a bag into the hopper of this feeding mechanism as the machine is driven through the field, keeping the dust level just above the agitator. This entirely does away with any danger of having the dust mixture either pack or form a hollow space around the agitator, such as frequently happens when ordinary dust hoppers are filled too full of material. With proper calibration of the device and careful driving of the truck the applications are almost never off more than 5 per cent from the desired dosage and very often they come out exactly right.

This device cost approximately $100, divided for the various parts as follows:

Engine (second hand)	$20.00
Hopper complete with screw, agitator, and framework (specially made)	61.00
Belts, pulleys, counter-shaft and bearings, bushings, and minor items	18.00

This was strictly a piece of experimental apparatus, and more time and material were consumed in making it than would have been required if there had been a guide or model to consult.

Fumigation with Methyl Bromide for Potato Tuber Worm

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During the autumn of 1941 a heavy infestation of potato tuber worms *Gnorimoschema operculella* (Zell.) developed in fall grown potatoes which were being stored for spring planting on the Eastern Shore of Virginia. During the severe outbreak of this insect in 1924 and 1925 Spencer & Strong made many tests with carbon bisulphide and hydrocyanic acid gas. They reported (1925) that neither of these materials were as effective as desired. Mackie (1938) reported that in California 375 car loads of potatoes had been fumigated with methyl bromide for the control of the potato tuber worm. The insecticidal properties of this new fumigant were first reported by Le Goupil (1932). In addition several other French and American workers have investigated the insecticidal properties of this fumigant and found it to have a wide field of usefulness.

As a result of these reports it was decided to fumigate these potatoes with methyl bromide. In correspondence, Dr. Lon A. Hawkins, In Charge Division of Control Investigations, reported that Mr. A. C. Johnson, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, had obtained complete control of all stages of the potato tuber moth by fumigating with a dosage of 2.4 pounds of methyl bromide per 1000 cubic feet for three hours at 80° F. He stated further that he thought it would be perfectly safe to drop the temperature to 70° F. Dr. Hawkins and Mr. W. H. White, In Charge Truck Crop Insect Investigations, arranged for Dr. Heber C. Donohoe and Messrs. W. D. Reed and Ross W. Brubaker to collaborate in the fumigation of these potato storage houses.

The first house fumigated was of a semi-cellar construction, the floor of which was about three feet below the surface of the ground. The sides were of brick and concrete construction. One end was tightly constructed but the other end was made of rough siding with many wide cracks, all of which were sealed with builders tape. Two ventilators on the tightly shingled roof were packed full of burlap bags. The windows and door did not fit closely so they were covered with heavy wrapping paper and sealed around the edges with gummed paper. The house was 22 by 40 with an average height of 10 ft. 6 in. It contained more than 500 bushels of heavily infested potatoes stored in bags, barrels, and baskets. The temperature ranged from 70° F. in the barrels to 74° F. in the upper part of the room. Twenty-two pounds of methyl bromide (2.38 lbs. per 1000 cu. ft.) were liberated in the house between 4:50 and 5:25 P.M. on October 27, 1941. A standard applicator to which an ordinary spray nozzle was attached was used in liberating 1-lb. cans of methyl bromide in all of the tests. The air was circulated in this and all other houses by means of a 16-inch electric fan while the methyl bromide was being liberated and for 15 minutes thereafter. The house was kept tightly closed until 8:25 P.M. when the door was opened and the building allowed to air out.

The next morning thousands of dead tuber worm larvae were found lying on the floor around the barrels and baskets. In addition more than 100 worms were dug out of the potatoes from various parts of the house, and all were dead. A large number of pupae were collected and these were all dead. Wasps hibernating in the storage house were also killed by the fumigation.

The second storage house to be fumigated was a flat roofed stucco building 20 by 40 by 10 feet. It was nearly filled with potatoes stored in barrels, three tiers deep. It was very tightly constructed and ideal for fumigation. The temperature was 75° F. both inside and outside the barrels. Nineteen pounds of methyl bromide (2.375 lbs. per 1000 cu. ft. of space) were released between 10:00 and 10:25 A.M. on October 28, 1941. The house was kept tightly closed until 1:25 P.M. when it was opened and the building aired out.

Here again, thousands of dead tuber worms were found on the floor around the barrels and more than 100 dead larvae were dissected out of the potatoes which were taken from various parts of the building. No living worms, pupae, or moths were found in this house.

A third storage house was fumigated on October 30, 1941. It was of brick construction, 18 by 28, with an average height of 10 ft. 6 in. All cracks around windows and doors were closed with heavy wrapping paper or builders tape. It was about one-third filled with potatoes which were stored largely in burlap bags. The temperature in this house was 75° F. both inside and outside of the potato bags. Thirteen pounds of methyl bromide (2.46 lbs. per 1000 cu. ft.) were liberated in this room between 12:05 and 12:20 P.M. The house was opened at 3:20 P.M. and aired out. Here again, thousands of dead tuber worms were found and no living ones.

These three houses were examined from time to time throughout the winter. No living worms were found in the houses and the potatoes kept as well as or better than might have been expected considering the condition they were in at the time of fumigation. Most of these potatoes were cut and planted in the spring of 1942. As far as could be determined, the methyl bromide did not have any injurious effect on the potatoes, as they sprouted and grew in the normal way.

Tuber worms continued to feed in and damage check lots of potatoes taken out of these houses before they were fumigated.

During the summer of 1942, potatoes kept in a large storage house at Hampton, Virginia for use in making potato chips became so heavily infested with potato tuber worms that they had to be discarded. Then this storage house was tightly closed and fumigated with methyl bromide to kill the many tuber worm moths and pupae that remained, so it would be safe to refill the house with potatoes. The fumigant was used at a dosage of 2.4 pounds per 1000 cubic feet of space and the house was kept tightly closed for 36 hours before it was aired out. Excellent control was obtained, as no live moths were found after the fumigation and no tuber worms developed in the potatoes that were later stored in this house.

SUMMARY.—Fumigation with methyl bromide gave excellent control of the potato tuber worm in heavily infested potatoes in three storage houses on the Eastern Shore of Virginia. Also, it gave excellent control of tuber worm pupae and moths in a large storage house at Hampton, Virginia. The methyl bromide was used at a dosage of approximately 2.4 pounds per 1000 cubic feet of space and the fumigation lasted for three hours.

Further, the fumigation did not have any noticeable effect upon the potatoes as they kept well and sprouted and grew normally when planted the following spring.

Caution: Although methyl bromide is not as poisonous as some fumigants, if inhaled its vapors are toxic to human beings as well as to insects and animals. Every precaution should be taken to avoid breathing air containing methyl bromide and to keep others away from buildings or rooms being fumigated. A gas mask should be worn when it is necessary to enter spaces containing methyl bromide.—5-19-44.

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Winter Distribution of Two Ectoparasites of the Cottontail Rabbit in Missouri

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For the last two winters, during January and February in 1943 and 1944, Field Biologists of the Missouri Conservation Commission have collected rabbits from thirty-eight different soil type sample areas distributed throughout the state. These rabbits were collected for an ecological study of the cottontail, by the Conservation Commission and the Missouri Wildlife Research Unit. However, the writer was given permission to examine the rabbits first and collect the ectoparasites.

An attempt was made to collect 10 rabbits from each area. As soon as an animal was shot it was placed in a paper bag with the collection data and the bag tied with a string. When the rabbits were received in the laboratory, they were placed in a refrigerator until they could be examined for parasites.

In 1943, the rabbit tick, *Haemaphysalis leporispalustris*, was found infesting the hosts taken from the areas in Jasper, Greene, Barton, Stoddard and Pemiscot counties. In addition to this tick, the rabbits shot in Pemiscot County were found to be infested with the partly engorged larval stage of the American dog tick, *Dermacentor variabilis*. These latter ticks were determined by Dr. F. C. Bishopp of the Bureau of Entomology and Plant Quarantine.

No rabbits were collected from the above mentioned counties this year, 1944, but one rabbit taken in Oregon County was infested with the rabbit tick. These counties are all located along the southern and southwestern borders of the state. All three active stages were found and some of each stage had been feeding. Many of the larvae and nymphs seemed completely replete while the mature males and females were only partly engorged. No ticks were found on any of the rabbits taken from the more northern counties in January and February.

These findings differ a little from those of Eddy (1942) in Oklahoma. He reported that the larvae and nymphs were active throughout the year. He also stated that no males were found to be active in December and no females in January or February, and that no replete specimens were taken until March 17. The Missouri counties where the infested rabbits were taken are approximately in the same latitude as the northern border of Oklahoma.

The collections made during the past two winters appear to show that the southern part of Missouri is just about the northern limit of the rabbit tick's year-round activity. This is important as this tick is a proven vector of tularemia and spotted fever between rabbits. As the ticks are seemingly active throughout the winter in the four or five rows of southern Missouri counties, it is possible that any rabbit shot may be infested with tularemia. Therefore, all the hunters should be warned against the careless handling of rabbits in southern Missouri.

Green (1939) in Minnesota has found that the ticks, some of which are probably infested with tularemia, go into hibernation during the winter and the rabbits are free of this disease. Therefore, we know that during January and February in northern Missouri where the ticks are hibernating that the rabbits may be handled with relative safety and used to help relieve the family's meat rationing problems.

A total of 667 fleas, representing five species, were taken from the 405 cottontail rabbits. The dominate species was *Cediopsylla simplex*, totalling 487 specimens, which was found infesting the rabbits from 34 of the 38 areas. The next was *Hoplopsyllus affinis*, totaling 96 specimens, and *Odontopsyllus multispinosus*, 82 specimens. These were also well distributed over the state, even though they were taken from only 12 areas each. There was only one specimen each of *Ctenophthalmus felis* and *Nosopsyllus fasciatus* collected.—6-26-44.

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Acerophagus Notativentris, an Important Parasite of the Grape Mealybug

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The grape mealybug, *Pseudococcus sp.*, in central California appears to be controlled by parasites.

Infestations of the grape mealybug commonly occur in spots of small area and are often localized to individual vines as pointed out by Nougaret (1921). The heaviest infestations from year to year are found where the Argentine ant is present, according to Wright (1930). In areas where the Argentine ant is absent other species of ants are held accountable for the size of the grape mealybug infestations. Nevertheless, infestations that are severe at the start of the harvest season often are cleaned up by the parasites before the end of the season.

Flebut (1922) considered the most important of these parasites to be the encyrtid *Acerophagus notativentris* (Girault). This species was observed by Nougaret (1921) to have parasitized 296 of 298 mealybugs removed from harvested grape clusters. He noticed that from 1 to 16 parasites can complete their development in a single mealybug. Clausen (1924) found the minimum life cycle under summer conditions to be 20 days. The reproduction of this parasite seems limited to the grape mealybug. It does not reproduce on any mealybug species known to attack citrus in California.

In 1943 from 100 to 200 *Acerophagus notativentris* were liberated on grapes near the city of Pasadena by the University of California.—7-11-44.

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Toxicity Tests of Some Organic Compounds and Their Hydrogenated Derivatives against Codling Moth Larvae

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This study was made to obtain data that might aid in predicting the insecticidal value of a compound to codling moth larvae, *Carpocapsa pomonella* (L.), from a knowledge of its chemical composition. Consequently the toxicity of some hydrogenated organic compounds has been compared with that of the unsaturated parent compounds.

The compounds were prepared for spraying by dissolving in ethanol (95 per cent) or, if insoluble, wetting with it, and then adding sufficient water to make the carrier contain 20 per cent of ethanol by volume. Most of the compounds that were soluble in ethanol were precipitated by the addition of water. All the compounds tested were applied at the rate of 4 pounds per 100 gallons of the carrier.

The tests were made in the laboratory by the apple-plug method. With a few exceptions, approxi-

Table 1.—Toxicity of carbocyclic compounds and their hydrogenated derivatives to codling moth larvae.

NAME OF COMPOUND	FORMULA	APPLE PLUGS	
		Wormy	Stung
		Per cent	*Per cent*
Phenyl acetate	$CH_3COOC_6H_5$	95	0
Cyclohexyl acetate	$CH_3COOC_6H_{11}$	94	2
Benzoic acid	C_6H_5COOH	95	2
Cyclohexanecarboxylic acid	$C_6H_{11}COOH$	99	0
Chlorobenzene	C_6H_5Cl	90	0
Chlorocyclohexane	$C_6H_{11}Cl$	99	0
Bromobenzene	C_6H_5Br	96	0
Bromocyclohexane	$C_6H_{11}Br$	95	0
Phenyl phthalate	$C_6H_4(COOC_6H_5)_2$	92	0
Cyclohexyl phthalate	$C_6H_4(COOC_6H_{11})_2$	87	1
o-Phenylphenol	$C_6H_5C_6H_4OH$	99	1
o-Cyclohexylphenol	$C_6H_{11}C_6H_4OH$	99	0
p-Phenylphenol	$C_6H_5C_6H_4OH$	99	1
p-Cyclohexylphenol	$C_6H_{11}C_6H_4OH$	98	0
Formanilide[1]	$HCONHC_6H_5$	90	1
N-Cyclohexylformamide[1]	$HCONHC_6H_{11}$	91	2
Propionanilide[1]	$C_2H_5CONHC_6H_5$	77	1
N-Cyclohexylpropionamide[1]	$C_2H_5CONHC_6H_{11}$	100	0
Lauranilide[1]	$CH_3(CH_2)_9CH_2CONHC_6H_5$	83	1
N-Cyclohexyllauramide[1]	$CH_3(CH_2)_9CH_2CONHC_6H_{11}$	100	0
Palmitanilide[1]	$CH_3(CH_2)_{13}CH_2CONHC_6H_5$	81	1
N-Cyclohexylpalmitamide[1]	$CH_3(CH_2)_{13}CH_2CONHC_6H_{11}$	98	0
Naphthalene	$C_6H_4C_4H_4$	94	1
Tetralin, or 1,2,3,4-tetrahydronaphthalene	$C_6H_4C_4H_8$	98	0
1-Naphthylamine	$NH_2C_6H_3C_4H_4$	95	2
5,6,7,8-Tetrahydro-1-naphthylamine	$NH_2C_6H_3C_4H_8$	94	0
1-Naphthol	$HOC_6H_3C_4H_4$	97	0
5,6,7,8-Tetrahydro-1-naphthol	$HOC_6H_3C_4H_8$	95	0
1,3-Di-1-naphthyl-2-thiourea	$(C_{10}H_7N)_2CS$	97	0
1,3-Bis(5,6,7,8-tetrahydro-1-naphthyl)-2-thiourea	$(C_{10}H_{11}N)_2CS$	99	0
2-Naphthoylacetonitrile	$C_{10}H_7COCH_2CN$	91	0
2-Tetrahydronaphthoylacetonitrile	$C_{10}H_{11}COCH_2CN$	96	0
Anthracene	$C_6H_4CHC_6H_4CH$	97	0
9,10-Dihydroanthracene	$C_6H_4CH_2C_6H_4CH_2$	58	11
Acenaphthene	$\overline{C_6H_3C_4H_3C_2H_4}$	92	1
Tetranaphthene	$\overline{C_6H_3C_4H_7C_2H_4}$	72	0
Lead arsenate	—	57	6
Check	—	94	0

[1] Taken from a previous report by Siegler & Bowen (1942).

Table 2.—Toxicity of heterocyclic compounds and their hydrogenated derivatives to codling moth larvae.

NAME OF COMPOUND	FORMULA	APPLE PLUGS	
		Wormy	Stung
		Per cent	*Per cent*
2-Furfuryl acetate	$CH_3COO(C_4H_3O)$	88	0
Tetrahydro-2-furfuryl acetate	$CH_3COO(C_4H_7O)$	95	0
2-Furfuryl alcohol	$(C_4H_3O)CH_2OH$	98	0
Tetrahydro-2-furfuryl alcohol	$(C_4H_7O)CH_2OH$	98	0
2-Furanilide[1]	$(C_4H_3O)CONHC_6H_5$	99	0
N-Cyclohexyl-2-furamide[1]	$(C_4H_3O)CONHC_6H_{11}$	90	0
Quinoline	$C_6H_4C_3H_3N$	90	0
1,2,3,4-Tetrahydroquinoline	$C_6H_4C_3H_6NH$	91	1
N-(2-Benzoxazolyl)aniline	$OC_6H_4NCNHC_6H_5$	95	0
N-(2-Benzoxazolyl)cyclohexylamine	$OC_6H_4NCNHC_6H_{11}$	98	0
Dibenzofuran	$C_6H_4OC_6H_4$	84	7
1,2,3,4-Tetrahydrodibenzofuran	$C_6H_4OC_6H_8$	92	3
2-Nitrodibenzofuran	$NO_2C_6H_3OC_6H_4$	83	1
7-Nitro-1,2,3,4-tetrahydrodibenzofuran	$NO_2C_6H_3OC_6H_8$	89	2
2-Acetyldibenzofuran	$CH_3COC_6H_3OC_6H_4$	96	0
7-Acetyl-1,2,3,4-tetrahydrodibenzofuran	$CH_3COC_6H_3OC_6H_8$	91	0
Carbazole	$C_6H_4NHC_6H_4$	80	1
1,2,3,4-Tetrahydrocarbazole	$C_6H_4NHC_6H_8$	93	0
Acridine	$C_6H_4CHC_6H_4N$	99	0
Acridan	$C_6H_4CH_2C_6H_4NH$	90	1
Acridone	$C_6H_4COC_6H_4NH$	95	2
1,2,3,4-Tetrahydroacridone	$C_6H_4COC_6H_8NH$	89	0
Lead arsenate	—	56	5
Check	—	93	1

[1] Taken from a previous report by Siegler and Bowen (1942).

mately 100 apple plugs, each infested with one ready-to-hatch codling moth egg, were used in testing each organic compound, and 600 plugs each were used for the lead arsenate and check tests.

The results are given in tables 1 and 2.

The most toxic compound was the hydrogenation product of anthracene, 9,10-dihydroanthracene, which permitted 58 per cent of wormy and 11 per cent of stung plugs. This result was approximately the same as that obtained with lead arsenate tests. Tetranaphthene also was considerably more effective than acenaphthene. On the whole, however, hydrogenation did not alter the toxicity of a compound.—3-24-44.

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Differentiating the Larvae of *Uranotaenia* in the Southeast[1]

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The genus *Uranotaenia* Lynch Arribalzaga is represented in the southeastern states by two species, *U. sapphirina* Osten Sacken and *U. lowii* Theobald. Dyar (1928) does not attempt to separate the larvae of these two species in his keys, and his descriptions of the larvae lack sufficient detail of various characters for accurate determination. King *et al.* (1942) separate *U. lowii* from *U. sapphirina* by the number of upper lateral hairs of abdominal segments I and

[1] Grateful acknowledgement is made to Col. Loren D. Moore, M. C., Commanding Officer, Fourth Service Command Medical Laboratory, and to the officers, enlisted men, and civilian personnel, both in the laboratory and in the field, who have through their efforts afforded the authors the opportunity to compile these data.

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II, those on *U. lowii* being double and on *U. sapphirina*, triple. However, because these hairs are often broken off, and because this character is valid only in fourth instar larvae, the need for supplementary diagnostic aids is evident.

At the Fourth Service Command Medical Laboratory large numbers of mosquitoes, both larvae and adults, are received weekly for identification from most of the army installations in the southeastern states. As a consequence, we have had an opportunity to study and compare large numbers of larvae of both *Uranotaenia sapphirina* and *U. lowii*, and characters have been noted which not only supplement the easily broken upper lateral abdominal hairs, but which can be used to identify the third instar. Because third instar larvae of *U. sapphirina* often have two instead of three upper lateral abdominal hairs on segments I and II, use of this characteristic alone frequently leads to confusion.

Table 1. Diagnostic differences between *u. sapphirina* and *u. lowii*

	U. sapphirina	*U. lowii*
Head (Side View)	A dark, roughly triangular spot between antennal base and eye (Fig. I-A).	Entire side of head dark, with exception of pale area surrounding eye (Fig. I-B).
Submedian Prothoracic hair tuft	Two long, heavy, serrated hairs extending to the base of the upper head spines or slightly beyond, and eight short, smooth hairs, not more than one-third as long as the serrated hairs (Fig. II-A).	Two long, heavy, serrated hairs extending to the base of the upper head spines or slightly beyond, one slightly shorter than the other and five shorter, serrated hairs, about two-thirds as long as the longer ones (Fig. II-B).
Head (Ventral View)	Usually with a broad, median pale area extending from the mentum to the collar, bounded by dark irregular areas on each side (Fig. III-A).	Always uniformly dark, with no median light area in the gular region (Fig. III-B).
Abdomen	Upper lateral hairs on abdominal segments I and II triple in fourth instar larvae. (King *et al.*)	Upper lateral hairs on abdominal segments I and II double in fourth instar larvae. (King *et al.*)

No exceptions have been noted in the prothoracic hair character or the post-antennal pigmentation character in third and fourth instar larvae. On rare occasions, however, *Uranotaenia sapphirina* have been found with lower side of head entirely dark, but this region is always dark in *U. lowii*. Besides the above characters, one can readily learn to recognize the head shapes as that of *U. sapphirina* is more rectangular than that of *U. lowii* (Fig. 1, II).

Specimens which are prepared as permanent slide mounts in chloral gum, balsam, or any other common mounting medium, usually clear after a period of time to such an extent that the pattern of the lower side of the head of *Uranotaenia sapphirina* becomes too indefinite to use as a character. Also, on permanent slide mounts, the lateral postantennal patches of pigment of *U. sapphirina* cannot be seen because of the position of the specimen on the slide. Obviously these characters are best seen if the larvae are preserved in alcohol or formalin so that pigment is retained and the specimens can be freely viewed from all angles under a binocular dissecting microscope. The submedian prothoracic hairs are plainly seen no matter which methods of mounting or preservation are used. In the large numbers of specimens examined, this character has not varied

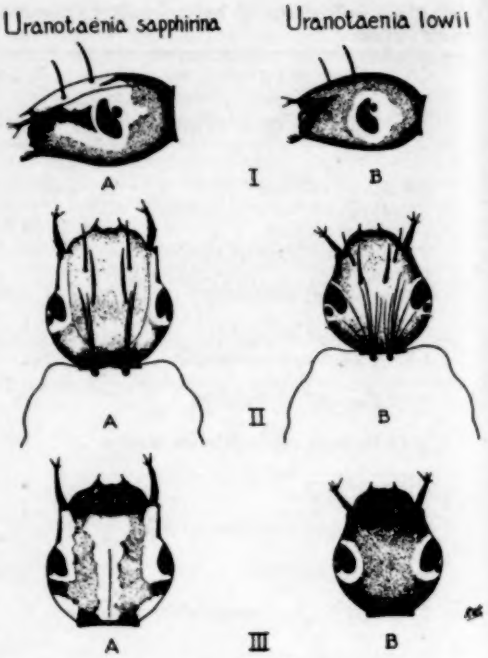

FIG. 1.—Diagnostic characters for two species of *Uranotaenia* larvae.

and is more reliable than the abdominal hairs noted by King, Bradley, and McNeel, since it holds in the third instar as well as the fourth.—4-8-44.

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Feeding Experiments with the Range Caterpillar Egg Parasite *Anastatus semiflavidus* Gahan

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Large numbers of the range caterpillar egg parasite *Anastatus semiflavidus* Gahan[1] were reared under artificial environmental conditions at the Tempe, Ariz., laboratory of the Bureau of Entomology and Plant Quarantine each year from 1930 to 1938. During 1932, 1933, and the early part of 1934 several series of experiments were made to find the optimum conditions for feeding and handling the material. This paper gives the results of the presence of different foods, water, and host eggs on the longevity of the parasite adults, particularly the females.

[1] Approximately 44 million eggs of the range caterpillar were parasitized. To accomplish this nearly 4 million parasites were fed and used in the stock cages.

The parasites were confined in glass-tube cages measuring 25 by 125 mm. In general, 5 insects were placed in each cage. The upper end of the cage was closed by a thin cork stopper. Liquid foods or water were supplied by saturating small wads of cotton, which were pushed into holes cut in this stopper. When solid foods were used they were placed on a cotton plug with which the lower end of the cage was closed. The experiments were made in a temperature-control room in which the temperature usually ranged from 75° to 80° F., with extremes of 73° and 84°.

TESTS WITH DIFFERENT FOOD MATERIALS.—The effects of various food materials on the longevity of females are shown in table 1. These records indicate very clearly that the life period is very short when no food or water is provided, whereas water alone only slightly increases the average life span. Feeding on the juices at oviposition punctures in eggs of the range caterpillar, as often noted under natural field conditions, apparently does not extend the average length of life. Solutions of honey, sugar, and sirup, and also dry rock sugar and water were all very effective in increasing the longevity of the parasite adults, the average life period being fairly uniform when any of these materials were fed. Orange juice, grapefruit juice, and soaked raisins were inferior to the sweet solutions and to dry sugar and water.

Table 1.—Effect of different foods on the longevity of *Anastatus semiflavidus* females.

FOOD SUPPLIED	FEMALES	LENGTH OF LIFE		
		Maximum	Minimum	Average
	Number	*Days*	*Days*	*Days*
None	225	5	1	2.9
Water only	200	18	1	4.2
Range caterpillar eggs	100	10	1	3.0
Honey solution, 1–4	175	76	3	33.9
Range caterpillar eggs and water	50	11	1	4.8
Range caterpillar eggs and honey solution	75	78	5	38.9
White-cane-sugar solution, 1–4	25	72	12	31.5
Brown-cane-sugar solution, 1–4	25	53	4	26.5
Sugarcane-sirup solution, 1–4	25	59	20	43.0
Commercial mixture of corn, sugarcane, and sorghum sirups, 1–4 solution	21	51	11	30.6
Rock sugar and water	50	55	14	33.3
Rock sugar only	25	36	5	10.7
Orange juice	50	44	5	17.2
Grapefruit juice	25	42	4	21.9
Raisins, soaked	25	15	2	7.9

DIFFERENT METHODS OF FEEDING HONEY SOLUTION AND WATER.—Using fresh honey solution, 1 part of honey to 4 parts of water, and also water alone, experiments were made to see whether there was an advantage in using water in addition to honey solution and whether honey solution should be supplied at frequent intervals. Table 2 gives the results of these experiments.

Table 2.—Effect of different methods of feeding honey solution and water on the longevity of *Anastatus semiflavidus* females. (Males and host eggs were supplied in each cage and each cage contained 24 or 25 females.)

FOOD SUPPLIED		LENGTH OF LIFE		
Honey Solution	Water	Maximum	Minimum	Average
		Days	*Days*	*Days*
Continuously	None	62	13	34.7
First day of life	After first day of life	7	3	5.1
First 3 days of life	After first 3 days of life	10	4	6.2
First day of life and each third day thereafter	On days when no honey solution was supplied	50	5	22.5
Continuously	Continuously	64	10	34.3

Judging by the results shown in table 2, additional water seems unnecessary when honey solution is supplied. Feeding honey solution for periods of 1 and 3 days following emergence apparently prolongs longevity by approximately the same length of time. Female parasites lived for fairly long periods when provided with honey solution every third day and with water on the intervening days, but the average longevity was 12 days less than when honey solution was available to the adult insects at all times.

RESULTS OF FEEDING FRESH AND FERMENTED HONEY SOLUTIONS.—Twenty-five females kept in cages with males and supplied with range caterpillar eggs and fed a fresh solution of 1 part of honey and 4 parts of water had maximum, minimum, and average longevities of 62, 13, and 34.7 days, respectively. A second group of 25 females given similar treatment in every way, except that they were fed a highly fermented honey solution made more than 6 months before, showed maximum, minimum, and average longevities of 58, 19, and 36.7 days, respectively. It is therefore evident that the average life periods of females fed on fresh and on fermented solutions of honey are about the same.

LONGEVITY OF MALES AND FEMALES OF ANASTATUS SEMIFLAVIDUS COMPARED.—By caging 45 males and 50 females and feeding them honey solution under identical conditions, longevity records were obtained which show maximum length of life for males, 38 days, for females, 76 days and a minimum for males of less than 1 day and for females of 27 days. From these results it seems reasonable to assume that the female of *Anastatus semiflavidus* has an average life span more than twice that of the male.

Economic Importance of Prolonged Pupal Periods of the Tobacco Hornworm

F. S. CHAMBERLIN, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Records obtained from a total of 3,613 larvae of *Protoparce sexta* (Johan.), collected in tobacco fields at Quincy, Fla., during the latter part of 5 harvesting seasons and placed in soil cages, showed a 6.4 per cent emergence of moths in the fall of the same year and a 25.7 per cent survival of overwintering individuals. Data published by Madden & Chamberlin (1938) show that one fall plowing of the soil in this

locality killed about one-half of the pupae present, which would otherwise have passed the winter successfully. An additional mortality would be expected to result from the several fall and winter cultivations usually given tobacco land in this producing area.

It has been known for some time that relatively few hornworms remain underground during the entire year following pupation and emerge as moths during the next season. Gilmore (1938) reported that a small percentage of pupae of *Protoparce sexta* hibernated 2 years or longer in the Clarksville, Tenn., area. Records of 1025 larvae taken from tobacco fields during the latter part of 2 growing seasons at Quincy, Fla., showed an average emergence of 0.6 per cent during the second following year. This relatively small emergence, together with the additional mortality resulting from cultivation, seems to indicate that these delayed adults would be too few in numbers to be of economic importance.

In the Georgia-Florida cigar-tobacco-producing area the practice of growing wrapper tobacco on the same land for several consecutive seasons is being abandoned. Under the plan now coming into general use, tobacco is grown on the same piece of land for 1 or 2 years, then followed by corn or some other crop for 1 or more years. Wrapper tobacco is grown under loosely woven cloth shading material attached to a wire frame supported by posts. These shade structures are very effective in excluding hornworm moths during the main part of the tobacco-growing season, provided the cloth tops and side walls are kept intact. During the latter part of the harvesting period the tobacco plants push their way through the tops to the outside, where they are available to the hornworm moths for oviposition. Although the main part of the crop has usually been harvested at this time, the resulting hornworm infestation frequently serves to populate the soil with overwintering pupae.

It was believed until recently that a shade structure situated on land on which crops other than tobacco or tomatoes had been grown the preceding season would be practically free of hornworm infestations developing from the soil covered by the structure. During the last two seasons, however, the writer's attention has been brought to several hornworm-infested crops of shade-grown tobacco on land planted to corn the preceding year. The cloth tops and side walls of these shade structures were found to consist of new shading material with no openings that would permit the hornworm adults to enter. The plants had not reached the shade tops and it was evident that the infestations originated within the structures. In each instance it was found that tobacco had been grown on the land 2 years earlier and had become rather heavily infested with hornworms during the latter part of the harvesting period. It is evident that a considerable number of individuals with prolonged hibernating stages developed on the preceding tobacco crops and that the resulting carry-over was sufficient to produce serious infestations in the shade-grown crop 2 years later, even though corn had been grown on the land during the intervening year.

As there is no satisfactory insecticidal control for hornworms on cigar-wrapper tobacco at the present time, infestations in this valuable crop assume considerable economic importance. While infestations may evidently originate from soil that grew tobacco 2 years earlier, no instances have been observed where such infestations have resulted after a 3-year interval. If hornworm control was the only important factor involved in rotations, the ideal practice would consist of growing shade-grown tobacco on the land for one season, followed by corn or some other suitable crop for two or more years before again planting tobacco.—3-6-44.

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Some Parasites of the Sweetpotato Weevil

K. L. COCKERHAM,[1] *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*[2]

Although the sweetpotato weevil, *Cylas formicarius elegantulus* (Summers), is an old and well-established insect in the Southern States and has been the subject of considerable investigation, there have been, prior to this paper, no authentic published records of parasites of this pest.

Early in August 1940 L. D. Newsom, research assistant of the Louisiana Agricultural Experiment Station at Baton Rouge, La., working cooperatively on the sweetpotato weevil project of the Bureau of Entomology and Plant Quarantine, discovered a number of third instars of the weevil dead in their tunnels in sweetpotato vines. Each presented a characteristic blackened appearance, and a small cocoon of a hymenopterous parasite was attached to each. Twenty-four of these parasites were discovered during the month, five of which emerged. Another hymenopterous larva was found in tunnels, where it was actively feeding on weevil larvae. This species attacked from the exterior and made no cocoons. In September additional specimens were found. Adult parasites reared from these weevil larvae were identified[3] as *Microbracon mellitor* (Say) and *M. punctatus* Mues.

During September 1940 at Sunset, St. Landry Parish, La., the following parasites were recovered: *Metapelma spectabilis* Westw. was reared from a sweetpotato weevil larva or pupa taken from tunnels in *Ipomoea quamoclit*. Since larvae and pupae were put in the rearing dish together and most of this material was dead and dry when the parasite was discovered, we were not certain from which it emerged. Five cocoons taken from sweetpotato weevil tunnels in sweetpotato vines, one of which was attached to a dead weevil larva, were identified as *Microbracon* sp., probably *punctatus* Mues.

During the fall of 1941 at Sunset, La., a number of parasites were found in sweetpotato weevil tunnels in wild host plants, some of which were actually feeding on the weevil larvae. From *Ipomoea hep-*

[1] The author acknowledges the assistance of O. T. Deen in making the observations at Sunset, La.

[2] This work was performed in cooperation with the Louisiana Agricultural Experiment Station, the Louisiana State Department of Agriculture and Immigration, and the Divisions of Control Investigations and Domestic Plant Quarantines, U. S. D. A. Agr. Res. Admin., Bureau of Entomology and Plant Quarantine.

[3] All identifications referred to in this paper were made by the Division of Insect Identification, Bureau of Entomology and Plant Quarantine.

taphylla, seven larvae and twelve cocoons were recovered; from *I. quamoclit*, one larva and three cocoons were recovered; from *I. hederacea*, one dead adult was recovered. All of the specimens taken from these wild hosts were transferred to petri dishes and placed in a constant-temperature cabinet. All of the adults reared from this material were identified as *Microbracon punctatus* Mues., and the cocoons were identified as *Microbracon* sp.; and, since no other host species was recovered, some of these specimens were actual weevil parasites.

Little is known concerning the economic importance of these parasites on the sweetpotato weevil. Observations and investigations are being continued with the objective of determining more definitely their economic importance in the natural control of the sweetpotato weevil.—4-26-44.

A Mixture of Pyridine and Iso-amyl Alcohol Attractive to Some Species of *Blepharoneura*

DONALD F. STARR, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

During tests of the chemotropic action of a large number of compounds and mixtures on fruitflies occasionally some other species are particularly attracted to certain of the lures tested. Such observations may provide useful information for those desiring to collect these or related species, and add to the available data regarding insect attractants.

In January 1942 several specimens of the genus *Blepharoneura*,[1] family Tephritidae, were captured in the glass fruitfly traps hanging in a mango grove near Cuernavaca, Morelos, Mexico. The lures tested and the distribution of the catch were such that the attractiveness of a mixture of equal volumes of pyridine and iso-amyl alcohol was definitely indicated. The counts in the field were made before it was known that there were two species involved; therefore no attempt was made to distinguish the two.

Table 1.—Comparison of the effectiveness of different lures for two species of *Blepharoneura* in a mango grove near Cuernavaca, Morelos, Mexico, January 20-28, 1942.

LURES	CATCH PER TRAP PER DAY[1]
1. Sucrose, 8 per cent; dried beer yeast 0.15 per cent fermented 1 to 2 days at 22° to 28° C.	0.02
2. Piloncillo, 10 per cent; alcohol 10 per cent by vol.	.00
3. No 2 plus 1 per cent by vol. of 1:1 pyridine and iso-amyl alcohol	.29
4. No. 2 plus 2 per cent of 1:1 pyridine and iso-amyl alcohol	.21
5. Sucrose, 8 per cent; alcohol 10 per cent	.00
6. No. 5 plus 1 per cent of 1:1 pyridine and iso-amyl alcohol	.10
7. No. 5 plus 2 per cent of 1:1 pyridine and iso-amyl alcohol	.66
Significant difference, $P=0.05$	.17[2]

[1] Six traps of each lure for each of two periods.

[2] Based on an analysis of variance of counts transformed to $\sqrt{n+0.5}$.

Small numbers of these flies were captured from time to time during the period 1940–42. Out of a total of 156 captured, however, 139 were taken during the 3-month period December 1941 to February 1942. None of these flies were observed during January 1944, but a few were caught during April or May in 3 different years. Data for the period January 20–28, 1942, when the maximum number of flies were trapped, are given in table 1, which also includes descriptions of the lures tested.

All four of the lures containing the pyridine-iso-amyl alcohol mixture caught more flies of the genus *Blepharoneura* than their respective controls and three of the four were significantly attractive. Lure No. 7 was the most attractive one in the group but there was no opportunity to study the relative values of the various constituents. Lure No. 1 was included because it is the fermented sugar solution which is attractive to *Anastrepha ludens* (Loew), (McPhail 1937).—5-4-44.

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[1] Statement from Dr. Alan Stone of the Division of Insect Identification, Bureau of Entomology and Plant Quarantine: "*Blepharoneura* sp., (longer ovip.), No. 1; *Blepharoneura* sp., (shorter ovip.), No. 2. These would both run to *fulvicollis* v. d. W., which has been synonymized with *poecilosoma* Schin., but it is impossible to say which, if either, is *fulvicollis*. It appears that the genus is a large one with many species, very few of which have been described."

Distribution and Prevalence of the Mosquitoes of Kentucky

GRIFFITH E. QUINBY,[1] ROBERT E. SERFLING, and JOE K. NEEL

The first known collections of mosquitoes in Kentucky were made in 1893 by H. Garman (1901) and his associates at the Agricultural Experiment Station, Lexington, Kentucky. Martha Didlake, working with Dr. Garman, later collected mosquitoes incidental to other insect studies over a period of several years. These two collectors made available to the senior author both determined and undetermined specimens. Dyar (1922) listed four collections made at Corbin by H. S. Barber on August 24, 1904. In the late 1920's and early 1930's Drs. Roy W. Feemster and George Lawson, both formerly of the University of Louisville Medical School, are known to have collected mosquitoes for educational uses but no taxonomic records were made.

In 1934 a comprehensive survey of the mosquito fauna of this state was begun by the senior author while employed by the Louisville City Health Department. This survey was continued in 1935 under

[1] The senior author is indebted to Dr. W. V. King, Dr. Robert Matheson and Dr. Alan Stone for confirmation of difficult or doubtful specimens. For assistance in identification and tabulation, we thank Mr. Benjamin Lawton, Dr. John Rayl, and Mrs. Lenior Nielsen Graf. The authors also acknowledge with gratitude the direction and guidance of Mr. George H. Bradley, in preparation of this report.

DISTRIBUTION AND PREVALENCE OF MOSQUITOES IN KENTUCKY

R = Rare
C = Common
x = Species present but abundance unknown.

SP. REF. NO.	SPECIES	COUNTIES	ALLEN	ANDERSON	BALLARD	BELL	BOONE	BOYLE	BULLITT	CALDWELL	CALLOWAY	CAMPBELL	CARLISLE	CARROLL	CARTER	CHRISTIAN	CRITTENDEN	DAVIES	EDMONSON	FAYETTE	FULTON	GALLATIN	GRAVES	GRAYSON	HANCOCK	HARDIN	HARLAN	HARRISON	HENDERSON	HICKMAN	HOPKINS	JEFFERSON	JESSAMINE	KENTON
1	*ANOPHELES BARBERI* COQ.				R						R		R			R									R				R		R			
2	*A. CRUCIANS* WIED.												R			R					C		R		R						R		R	
3	*A. PUNCTIPENNIS* SAY		C	C	C	x	C	C	C	C	C	C	C	C	x	C	x	C	x	x	C	x	C	x	C	x	x	C	C	C	C		C	
4	*A. QUADRIMACULATUS* SAY				C		R	C	C	C	C	R	C	x		C				x	C	x	C	x	C		x	C	C	C	C		C	
5	*A. WALKERI* THEOB.																				C													
6	*AEDES AEGYPTI* (L.)															x				x	x										C			
7	*A. CANADENSIS* (THEOB.)		x				x									x								x	C			x		C	R			
8	*A. DORSALIS* (MEIG.)																														R			
9	*A. DUPREEI* (COQ.)															R									R									
10	*A. FULVUS PALLENS* ROSS																				R													
11	*A. GROSSBECKI* D. & K.																													R				
12	*A. INFIRMATUS* D. & K.																								R									
13	*A. NIGROMACULIS* (LUD.)																														R			
14	*A. STICTICUS* (MEIG.)		x		C				R				C			x					C		C		R			C	C	C	R			
15	*A. TRIBAULTI* D. & K.				R								R										R											
16	*A. TRISERIATUS* (SAY)		C		C				x	C			C			x					C	x			C			C		C	C	C		x
17	*A. TRIVITTATUS* (COQ.)																								C						R			
18	*A. VEXANS* (MEIG.)				C				C	C			C			x		x		x	C		C		x	C			C		C	C		
19	*CULEX APICALIS* ADAMS			x	C		x		x	x		x	C	x		x					C		C			C	x		C	x		C		x
20	*C. ERRATICUS* D. & K.							C	x	x				x		x					C		C			C			R			C		x
21	*C. PECCATOR* D. & K.							R								R															R			
22	*C. PILOSUS* (D. & K.)							R																										
23	*C. PIPIENS* L.				x			x		x						x				x	x								x	x		x		x
24	*C. QUINQUEFASCIATUS* SAY				x			x								x				x	x				x				x					
25	*C. RESTUANS* THEOB.			x	C				x	x	x		C			x	x	x			C		x		C			x	x	x	C			
26	*C. SALINARIUS* COQ.				R			x	R	R											R				x			x	R		R			
27	*C. TARSALIS* COQ.															R					R		R		R						R			
28	*PSOROPHORA CILIATA* (F.)				C				C							C					C		C		C						C	x		
29	*P. CONFINNIS* (L.-ARR.)								C							C					C		C		C			x			C			
30	*P. CYANESCENS* (COQ.)				C				C							C					C		C		C				C		C			
31	*P. DISCOLOR* (COQ.)								C							C							R		C			R			R			
32	*P. FEROX* (HUMB.)				C				C							x				x	C		R		C			x	C	C	C			
33	*P. HORRIDA* (D. & K.)								x							R					R		R		R						R			
34	*P. HOWARDI* (COQ.)																				R		R		R						R			
35	*P. SIGNIPENNIS* (COQ.)																						R											
36	*P. VARIPES* (COQ.)				R				R												R		R		R						R			
37	*CULISETA INORNATA* (WILL.)								R							R				R	R		R		R			R	R		R			
38	*C. MELANURA* (COQ.)																						R					R			R			
39	*MANSONIA PERTURBANS* (WALK.)																				C				R						R			
40	*MEGARHINUS SEPTENTRIONALIS* D. & K.																			R					R									
41	*ORTHOPODOMYIA SIGNIFERA* (COQ.)															R				R			R		R									
42	*URANOTAENIA SAPPHIRINA* (O.-S.)				R			R	x							R					C		R		C	x		R			x			

DISTRIBUTION AND PREVALENCE OF MOSQUITOES IN KENTUCKY

KNOX	LAUDE	LAUREL	LIVINGSTON	LYON	MADISON	MARSHALL	McCRACKEN	MEADE	MERCER	MUHLENBERG	OHIO	OLDHAM	PULASKI	SCOTT	SIMPSON	TODD	TRIGG	UNION	WARREN	WHITLEY	SP. REF. NO.	FIRST KENTUCKY RECORD			
							R	R													1	6/8/33	WICKLIFFE	BALLARD	G.E. QUINBY (9)
R		R			R		R			R								R		R	2	6/1/35	McGEE SPRINGS	CARLISLE	G.E. QUINBY (9)
C	C	C	C	C	C	C	C	C	C	C		C	C	C	C		C	C	x	C	3	1/9/97	LEXINGTON	FAYETTE	H. GARMAN (6)
	R		C		C	C	C	C	R	C				R				C			4	9/20/00	LEXINGTON	FAYETTE	H. GARMAN (6)
							R														5	9/7/39	BONDURANT	FULTON	F.B. BANG
							x														6	10/5/98	LEXINGTON	FAYETTE	H. GARMAN (6)
x		x					x	C			C						x	R		x	7	8/24/03	CORBIN	WHITLEY	H.S. BARBER (5)
																					8	6/28/42	LOUISVILLE	JEFFERSON	R.E. SERFLING
								R													9	6/16/41	GARNETTSVILLE	MEADE	G.A. CHISM
																					10	9/2/40	BONDURANT	FULTON	T.W. SIMPSON
																					11	4/23/36	CLINTON	HICKMAN	A.W. WILSON
																					12	6/13/41	FT. KNOX	HARDIN	W. BOAZ
							R														13	7/7/42	PADUCAH	McCRACKEN	R.E. SERFLING
				C			C	R			C						x	x			14	6/1/35	McGEE SPRINGS	CARLISLE	G.E. QUINBY (9)
							R														15	8/4/37	3 MI. S. WICKLIFFE	CARLISLE	G.E. QUINBY
	x			x			C	C		C	C						x	C	x	x	16	9/24/04	CORBIN	WHITLEY	H.S. BARBER (5)
							R	C										R			17	5/27/36	LOUISVILLE	JEFFERSON	G.E. QUINBY (9)
	x	x		x			C	C			C					x	x	C	x		18	9/16/15	LEXINGTON	FAYETTE	H. GARMAN
x	x	x		x			C	C		x		C						C		x	19	6/13/35	LOVELACEVILLE	BALLARD	G.E. QUINBY (9)
x							C	C	x	x								C			20	6/24/36	PADUCAH	McCRACKEN	G.E. QUINBY (9)
							R			R											21	9/28/36	PADUCAH	McCRACKEN	R.E. TEAGUE (9)
							R														22	9/24/37	DANVILLE	BOYLE	G.E. QUINBY (9)
							x					x			x		x				23	9/14/01	LEXINGTON	FAYETTE	H. GARMAN
																					24	9/22/01	LEXINGTON	FAYETTE	H. GARMAN
	x				x		C	C				x			x		x	x	x		25	6/3/35	HICKMAN	FULTON	G.E. QUINBY (9)
			x				x	x		x								R		x	26	2/23/36	6 MI. N.E. SHEPHERSDVILLE	BULLITT	G.E. QUINBY (9)
							R											R			27	6/3/35	MILLER	FULTON	G.E. QUINBY (9)
	x						C	C										x			28	8/23/93	20 MI. S.W. LEXINGTON	JESSAMINE	H. GARMAN (6)
	x						C			x								C		x	29	8/24/04	CORBIN	WHITLEY	H.S. BARBER (5)
	x						C	C									x	x			30	6/11/34	LOUISVILLE	JEFFERSON	G.E. QUINBY (8)
							R	C										R			31	9/21/38	LOUISVILLE	JEFFERSON	G.E. QUINBY (9)
							C	C		x							x	x		x	32	8/24/04	CORBIN	WHITLEY	H.S. BARBER (5)
							R	R										R			33	7/24/36	HICKMAN	FULTON	G.E. QUINBY (9)
							R	R													34	6/15/34	LOUISVILLE	JEFFERSON	G.E. QUINBY (8)
																					35	5/26/43	VIOLA	GRAVES	J.K. WEEL
							R														36	6/12/35	6 MI. N. BARLOW	BALLARD	G.E. QUINBY (9)
							x					x						R			37	9/7/35	LEXINGTON	FAYETTE	M.D. DIDLAKE
																		R			38	5/10/43	STURGIS	UNION	R.E. SERFLING
							R														39	6/25/34	LOUISVILLE	JEFFERSON	G.E. QUINBY (8)
								R										R			40	9/7/35	LEXINGTON	FAYETTE	M.D. DIDLAKE
							R	R										R			41	11/1/02	LEXINGTON	FAYETTE	M.D. DIDLAKE
x							C	C										R		x	42	6/26/35	WICKLIFFE	BALLARD	G.E. QUINBY (9)

Table 1.—Number of collections and specimens for counties in Kentucky.

COUNTY	COLLECTIONS	SPECIMENS
Allen	18	39
Anderson	3	27
Ballard	74	1,230
Bell	1	2
Boone	7	37
Boyle	10	266
Bullitt	342	2,961
Caldwell	77	718
Calloway	6	66
Campbell	1	4
Carlisle	52	1,131
Carroll	2	6
Carter	1	4
Christian	1,608	11,660
Crittenden	1	8
Daviess	10	57
Edmonson	1	4
Fayette	45	124
Fulton	182	3,183
Gallatin	2	7
Graves	1,285	11,571
Grayson	1	7
Hancock	1	18
Hardin	2,765	32,146
Harlan	2	4
Harrison	1	4
Henderson	332	1,750
Hickman	93	974
Hopkins	31	708
Jefferson	2,947	36,635
Jessamine	1	2
Kenton	10	65
Knox	2	57
Larue	148	1,538
Laurel	3	79
Livingston	11	123
Lyon	9	31
Madison	33	465
Marshall	9	159
McCracken	1,855	17,809
Meade	215	1,875
Mercer	18	303
Muhlenberg	9	108
Ohio	29	1,280
Oldham	4	48
Pulaski	1	46
Scott	2	6
Simpson	3	15
Todd	1	1
Trigg	20	178
Union	1,266	7,979
Warren	8	19
Whitley	3	35
TOTALS	13,563	137,572

the auspices of the Kentucky State Health Department, and late in 1935 under the United States Public Health Service. Under either state or federal auspices the work was continued by the senior author until 1942, when it was taken over by Robert Serfling of the Malaria Control in War Areas Program of the United States Public Health Service, who has been assisted since 1943 by Mr. Neel.

Space prohibits individual recognition of many collectors who have contributed specimens to this study. However, special acknowledgment is due the cooperating collectors of the National Youth Administration and Malaria Control in War Areas, who provided the greater portion of specimens represented in this study.

The specimens on which the records contained herein are based may be found in the collections located at the following places:

(1) State Department of Health, Louisville, Ky.

(2) University of Louisville, Biology Department, Louisville, Ky.

(3) University of Kentucky, Dept. of Agriculture, Lexington, Ky.

(4) U. S. National Museum, Washington, D. C.

(5) U. S. Public Health Service, National Institute of Health, Malaria Investigations, Memphis, Tenn.

(6) Cornell University, Ithaca, N. Y.

(7) U. S. Department of Agriculture (Collection of King, Bradley, & McNeel.), Orlando, Fla.

SCOPE OF SURVEY.—This survey summarized in the accompanying table represents 137,572 specimens in 13,563 collections from 54 of the state's 120 counties.

Most of the collections were incidental to the malaria or mosquito control programs of the City Health Department of Louisville, the State Health Department of Kentucky, and the United States Public Health Service. In general, this survey was of necessity confined to areas and species of public health importance.—7-5-44.

LITERATURE ON MOSQUITOES OF KENTUCKY

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The Poisoning of Bees with Methods of Prevention[1]

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The relationship of the beekeeping industry to the application of insecticides and fungicides for the protection of plants has been an unhappy one from the time such materials were first applied in the control of insects and of fungus diseases. The honeybee must visit flowers to collect the pollen and nectar required for the maintenance of colony life and this habit brings it into close contact with many of the chemicals used for plant protection. It is also susceptible to the toxic effects of practically all of the insecticides that act as stomach poisons and to many of those that are useful as contact materials. The fact that the keeping of bees is followed as a commercial enterprise for the production of honey and beeswax as well as for the pollination of our major food and pasture crops adds to the seriousness of this difficult problem. The destruction of colonies by chemical poisoning reduces the beneficial effects bees have on the increased production of our food and pasture crops and seriously interferes with the welfare of the farmers as well as of beekeepers.

The solution of this problem of bee poisoning versus plant protection is complicated by the diverse interests of many groups. In the first place, the grower must protect his plants from injury by insects and fungus diseases. No one can deny him that right. The manufacturer of insecticides is interested in the sale of his product. The manufacturer of equipment for the distribution of insecticides is likewise interested chiefly in the production and sale of machinery that will spread the chemicals over growing plants. The commercial operator who buys this equipment for hire in the application of materials is concerned principally with the amount of the materials he can apply and the returns for his services received in a given period of time. Entomologists and crop specialists interest themselves primarily in recommending the various chemicals needed for plant protection. Entirely too few of these interests give any consideration to the detrimental effects that poisons may cause by their untimely application or by quantities that drift from the fields treated. Then there are the state and federal agencies which have the responsibility of enforcing regulatory measures designed to protect the grower, the ultimate consumer and other interests from injury by the misuse of the privilege of applying poisonous substances for the protection of plant growth. The beekeeper, the dairyman, the poultry producer, and many private interests are directly affected by not only the types of materials used but also with the time and manner of their application in so far as the poisons affect their rights or property.

The manufacture, sale and use of agricultural insecticides have now reached such vast proportions that the present legislative and regulatory measures designed to protect general interests against the promiscuous use of insecticides are entirely inadequate. This is evidenced by the thousands of colonies of bees that have been killed in California, Washington, Nevada, Utah, Texas and other states in recent years by poisons applied to growing crops. In one California county alone, between 1200 and 1500 colonies were killed and a large number injured by the application of calcium arsenate to tomatoes in 1943. Bees do not visit tomato plants, so the injury was caused by the poisons being applied in a manner or under conditions that caused them to be deposited on other vegetation for great distances beyond the fields treated. Over a million pounds of the same poison will be applied this summer in the same county without sufficient additional safeguards being taken to prevent a recurrence of such losses from the effects of poisons not confined to the fields treated. In many instances destruction of colonies has also followed when poisons were applied at times when bees were visiting the crops treated or fed on pollen and nectar of cover crops in sprayed orchards.

HOW BEES SECURE POISONS: Observations have shown that bees secure these poisons in the nectar they seek or in the pollen they gather and carry back to their hives. Contact sprays or dusts, as a rule, are seldom as injurious as stomach poisons used on growing crops. Bees that secure poison in nectar, commonly die before they reach their hives while those that carry poisoned pollen, carry the poisons back to their hives where it constitutes a source of destruction for the hive bees and the brood. The flying range of the honeybee will average one and one-half miles with greater distances not uncommon. Beekeeping or other agricultural industries seldom suffer any loss if plants are not sprayed or dusted when in bloom and if the poisons are confined to the fields treated. It is therefore obvious, that any poisons applied to a large area, whether to the crops in bloom or in a manner that would cause the poison to be distributed for great distances beyond the fields treated, is likely to cause serious injury to the interests of any beekeeper within flying range.

REASONS FOR MORE ADEQUATE CONTROL: It seems highly probably that there will soon be placed on the market new chemicals that combine not only the effects of contact and stomach poisons for a large variety of insects but also possess a permanency that few other insecticides have. The use of powered machinery and airplanes, for the distribution of millions of pounds of poisons is increasing rapidly and the manner in which they are used needs more adequate control measures just as did the automobile when it supplanted the horse drawn vehicles. So would it not seem the better part of wisdom for the manufacturers of insecticide equipment, the entomologists, horticulturists and other crop specialists to consider adequate control and regulator measures necessary to protect all interests from the misuse of the privilege of applying poisons, before other agencies are forced to enact such legislation to defend their properties against the ill effects of poisons? The beekeeping industry is a fundamental part of successful agricultural practices and in the interest of better agriculture and of increased food production must be protected from the injurious effects of the promiscuous application of insecticides.

SUGGESTED METHODS OF PREVENTING THE UNNECESSARY DESTRUCTION OF BEES: The poisoning of bees can be reduced to a minimum by (1) confining the poisons to the plants treated or so the materials will not drift from the fields in quantities sufficient to cause economic loss to others, (2) by not spraying or dusting crops in bloom, (3) by using materials that are least injurious to the interest of others, (4) and by using chemicals only when necessary and in quantities no greater than needed to do an efficient job.

The beekeepers and growers can cooperate with each other in preventing unnecessary losses, and the commercial operators of insecticide equipment can do a better job of confining the poisons to the crops

[1] From the Program of the Pacific Slope Branch Meetings, June, 1944.

treated, but additional regulations and laws should be enacted to insure against the misuse of poisons on growing crops. Such regulations should include, at least, the following considerations:

1. All colonies of bees and their locations should be registered with some county officer in the county in which they are located.

2. All persons using toxic substances in commercial quantities should be registered with the same county authorities and secure permits for the privilege of spreading such substances on weeds or agricultural crops.

3. All persons operating spray rigs or dusting equipment for hire should be licensed under a central state agency and post a bond to insure the faithful performance of all the requirements of law and for the protection of persons or property from damage or injury as a result of the spreading or applying of poisons; such persons should also be required to file intention of applying poisons and secure permits to do so from the authorities of the county in which the poisons are to be used.

4. Adequate federal, state and county regulations should be enacted (a) to limit the maximum tolerances of poisons on all food crops sold; (b) to limit the sale of poisons to responsible persons with suitable equipment for their distribution; (c) and to limit the distribution and manner of applying poisons to those times and means that will cause no substantial loss to the property rights and interests of others.

5. A regulatory agency in each county should have the authority in granting permits to growers or to commercial operators to specify the types of equipment to be used, the times and conditions under which the poisons can be applied, and the specific poison that can be used at the time of issuing such permits in order to safeguard against injury to the grower or to other interests.

In addition to these measures, some of which will take a long time to put into operation, those issuing recommendations for the chemical control of insect pests or fungus diseases should at the same time call attention to the injury such poisons may cause if they are not confined to the fields treated, or if they are applied during the blooming period of the plants. If such suggestions are contained in all printed releases containing recommendations for the use of agricultural insecticides and fungicides, the unnecessary loss of bees may be greatly reduced. It would also be reasonable to suggest that those who apply toxic substances in commercial quantities notify their neighbors before doing so.—7-13-44.

An Electrically Regulated Humidity Control[1]

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The apparatus for controlling humidity which is described in this paper has been used during 3 years in a study of the effects of temperature, humidity and certain foods on the migratory grasshopper *Melanoplus mexicanus* Saussure. Without reviewing the literature which pertains to the assembling of such equipment the writer wishes only to mention that efficient devices of this nature have been previously described, some similar in principle to the one discussed herein. The most satisfactory of these however, are comparatively expensive and rather bulky. Where chemical solutions of standardized concentrations are used, considerable bulk and much maintenance result.

The humidistat and humidifier described below are small and can be assembled as a unit including temperature controls, in a wood compartment 18 ×16×7 inches. This is attached to the rearing compartment or incubator at any convenient point. The unit should be hinged to the large compartment in such a way that it can be opened out. If the top is constructed as a lid this will facilitate maintenance. The whole unit can be built in from 12 to 14 hours.

Low humidities can be established by placing shallow trays of calcium chloride salt in the bottom of the incubator. If high humidities are to be held or if large compartments are to be humidified, shallow trays of water may be placed in the incubator or a device such as is described by Burrell (1930) can be used. The humidifier will regulate the humidity at any point for which it is set above that normally established. The described equipment without these aids will however, prove adequate for most experimental work. Constant temperature, prerequisite to constant relative humidity, can be satisfactorily controlled with a snap contact thermostat and 60-watt heating coils.

The writer hopes that others who have need for such equipment and who do not find it advisable to make expensive and permanent installations, will find here a solution to their problem with the result that humidity as an important related factor will be more extensively considered in the future.

EXPLANATION OF ASSEMBLY.—The basis for this device is the moisture sensitive coil from a good mechanical hygrometer. That part of the dial upon which this is mounted is cut into shape, bent and bolted to a small block of wood in such a way that it can be turned by the handle as is illustrated in the diagram. The coil is mounted on a small strip of metal which can be turned completely around, carrying with it the indicator needle. Thus the needle will point in a direction exactly opposite to its normal position. A small area of the needle near its tip is cleaned with a file and to this is soldered a tungsten electrode from a model T Ford coil point. The two outside electrodes (L) & (H) are of the same source but remain attached to the thin brass strip upon which they were originally mounted. These are screwed to the wood block as shown in the diagram and are held at about a forty-five degree angle to the central electrode, resulting in the central electrode making contact with its edge, an important feature due to the nature of electrical charges in flowing from points.

The distance between the outer electrodes can be changed by turning the adjustment screws (AS) up and down, the distance between these electrodes determining the extent of variation in relative humidity. When the central electrodecontacts (H), a circuit is completed through the mercury switch (A), relay (RA) and power magnet (MA). The magnet attracts a metal plate attached to the wood carrier in which the mercury switches are mounted, causing them to be rocked over in the opposite direction. This breaks the circuit through switch (C) and the fan in the humidifier stops. As the humidity in the incubator slowly drops, the needle of the humidistat carries the central electrode to (L) and the same procedure as described above occurs in reverse

[1] Portion of a thesis presented in partial fulfillment of the requirements for the degree Doctor of Philosophy at Kansas State College.

through (B), (RB) and (MB). This again completes the circuit through (C) and the fan is turned on.

MERCURY SWITCHES AND RELAYS.—The most important feature of this assembly is that it should be very sensitive. This is accomplished through accuracy in construction. The switches must be perfectly in line when mounted in the wood block (SB). The axles of this block are made from brass cup hooks and should turn freely in their wood supports (S_1 and S_2). The magnets (MA and MB) are from headlight relays. They are mounted as closely as possible to the metal plates attached to block (SB) for magnetic attraction, allowing space for effective rocking of the switches. The relays and electric bulbs (which serve only as resistances) are mounted on the base board of this unit.

The moveable electrode of the relay should be fixed as close to the stationary one as possible without making contact. It is also well to weaken the spring so that very little current will be needed for good operation.

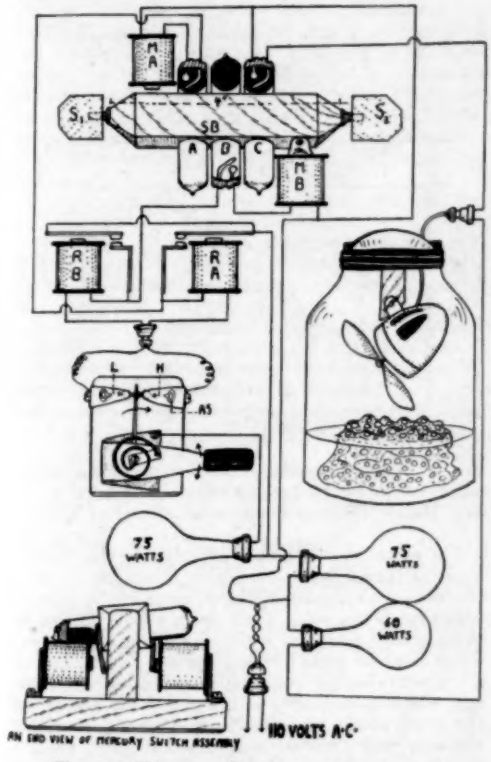

FIG. 1.—Diagram showing arrangement of apparatus described.

When the whole assembly is completed it must be placed so that the mercury switches are perfectly balanced between their two positions. A good test for efficiency is to hold the switches down with the fingers, connect the power magnet with the humidistat and see whether or not the switches are vigorously rocked over.

HUMIDIFIER.—Many schemes have been conceived for humidifying air. Other devices than the one discussed, using fans or electrically operated units, may be used. The writer believes, however, that most of them would be somewhat more difficult to set up and would have few advantages.

A cheap 8-inch fan is cut down to 4 inches. Removed from its base it can be bolted to a piece of wood which is firmly screwed to another wood block mounted on the lid of the jar. This lid is partially cut in such a way that portions of it are bent up in the form of fins. The jar is an ordinary gallon fruit jar such as can be obtained at nearly any grocery store. In the jar is placed a sponge which serves to prevent water from spraying on the fan and also increases the surface area for evaporation. Efficiency is further increased by placing the heating element which controls temperature for the incubator against the lower part of the jar. Distilled water should be placed in the jar. This can be replaced from time to time with a funnel and a rubber hose or whenever the fan is removed for oiling. A drop or two of iodine in the water will prevent plant growth.

In the wiring diagram it will be noted that a 60-watt electric bulb has been placed in series with the fan. This slows down its speed and prevents humidity from building up too rapidly. If a large incubator unit is used it would be desirable to run the fan at greater speed by using a bulb of higher wattage.

CARE AND OPERATION OF THE APPARATUS.—Once this unit has been properly installed and set there is very little maintenance. A small amount of oil must be placed on the bearings of the humidifying fan every week or two, depending upon the amount of time it runs. From time to time the electrodes may corrode slightly. When this occurs a small piece of extremely fine carborundum paper should be used for cleaning them.

A fan placed in the opening between the control unit and the main incubator should be operating constantly, otherwise uniform conditions will not occur throughout. The rotation of this fan may also be satisfactorily regulated by placing an electric bulb in series with its circuits.

Temperature and humidity within the incubator can be observed at any time by installing a good mechanical humidity guide[1] and thermometer in the compartment. This instrument should be carefully checked for accuracy. Any error which it may have can easily be corrected by adjusting the parts when it is removed from its case.

Most of the parts in the temperature and humidity control unit can and should be connected into the circuit by means of plugs as shown in the diagram. This makes it possible to dismantle the assembly quickly for repairs or storage. The total cost of the parts is approximately $20.00.

CONCLUSIONS.—The satisfactory control of constant relative humidity has offered a problem in biological research for many years. Either the cost of equipment, the time required in maintenance or both have usually been prohibitive.

It is felt by the writer that the unit described in this paper is so inexpensive that many of them could be considered for a single project. They could be assembled by students, or skilled labor in ☭ supplies department. The unit is adequate for maintaining desired atmospheric conditions in any ordinary rearing compartment.—4-30-44.

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[1] *Airguide*, Fee and Stemwedel, Inc., Chicago.

An Adaptation of a Thermograph to Regulate Variable Temperature[1]

FRANCIS MUNGER, *U. S. D. A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

In connection with biological studies of the California red scale, *Aonidiella aurantii* (Mask.), it was desired to investigate the effect of certain fluctuating temperature patterns on the life of the insect. Devices for controlling variable temperature have been described by Stone (1939) and Wishart (1940), but since the equipment for constructing either of these instruments was not at hand, it became necessary to control the temperature by a somewhat different method.

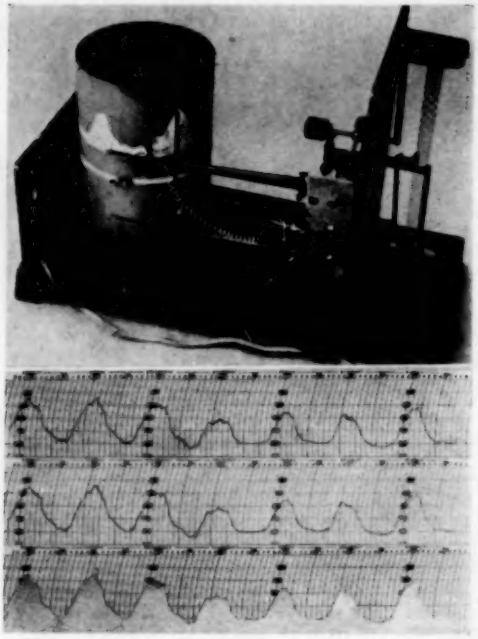

FIG. 1.—Electrical attachments for adapting hygrothermograph to regulation of variable temperature (above) and original thermograph record; thermograph record of laboratory reproduction, and tracing paper copy of original chart (lying on blank chart), used to transfer record to chromium-plated cylinder (below).

The method used calls for a standard thermograph, a source of direct current, and a relay coil having a current drain of 10 to 15 milliamperes at 3 volts. No permanent changes in the thermograph are necessary, and only three readily attachable parts (Fig. 1) are required—(1) an electrically insulated metal contact point to replace the pen on the recording arm; (2) a piece of sheet metal, which is fastened to the clock drum in place of the thermograph chart; and (3) an insulated, twin binding post, to be clamped to the bearing arms of the thermograph.

The conductive unit (Fig. 2) consists of a sharpened platinum or silver rod (*1*), approximately 0.004 inch in diameter, to act as a brush, soldered (*7*) to a copper wire (*2*). The copper wire is looped and partially flattened to allow it to lie against a strip of mica insulation (*4*). On the opposite side of the mica is a brass sleeve (*3*) which is made to fit onto the end of the thermograph recording arm in the manner of the pen. The three parts, as shown in the sectional view, are bound together with thread, and the thread is finally treated with lacquer. A lacquered wire coil (*6*) is soldered (*8* and *9*) to the copper wire (*2*) and to a copper terminal (*5*). For strength and flexibility, this coil is best made of No. 40 constantan wire.

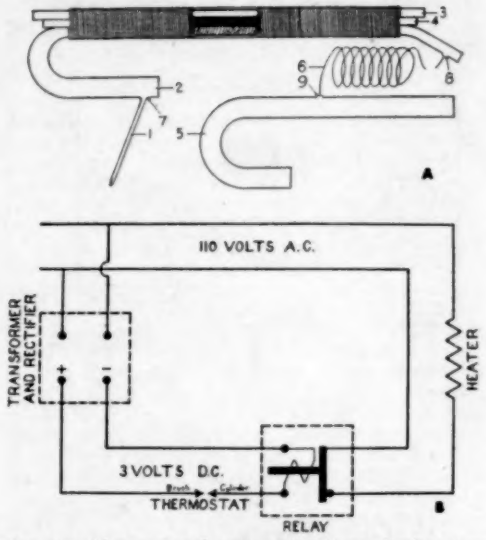

FIG. 2.—Above: Insulated conductive unit showing metal brush for contacting chromium-plated cylinder; Below: Wiring diagram of electrical system.

The metal sheet which is attached to the clock is made of tinned iron plated with chromium. It is in the form of a cylinder, either soldered at the seam or left open. If the seam is left open, a tight fit can be obtained by means of a circular clamp. The chromium must be plated with a current density and at a temperature that will produce a dull or rough surface, which is necessary in order to keep the tip of the brush clean, and thus to insure good electrical contact. Such a surface may be obtained by using a standard chromic acid-sulfuric acid plating bath at 75° F. A 6-volt storage battery has sufficient current to plate from 3 to 4 square inches of surface at a time, using a lead anode 3 inch s square. During operation the thermograph is tilted back at an angle of 12 degrees to increase the pressure of the point of the brush on the chromium. At the end of each 2 weeks of service the brush is resharpened and cleaned.

The temperature program to be reproduced is first drawn on the metal with a pencil, using a tracing-paper stencil as a guide. The area below the line for about half an inch downward is then painted with a hard-drying automobile lacquer.

[1] The writer is indebted to W. E. Stone for suggesting the construction of such an instrument. (While visiting the Mexican laboratory of the Division of Fruitfly Investigations, C. I. Bliss explained to Mr. Stone the principle upon which he had seen an instrument of this type operating in Russia.) He is also indebted to R. A. Fulton for recommending the use of chromium as an electrical contact, and to J. K. Holloway for electrical help.

The 3-volt current which controls the relay is made to pass through the metal of the thermograph, with the relay coil in series. The negative lead is attached to any convenient place on the thermograph frame, and the positive lead and the copper terminal (*5*) (Fig. 2) are both attached to the insulated binding post. This arrangement is necessary to prevent oxidation of the chromium surface. A wiring diagram is also shown in figure 2. The instrument is placed in the compartment to be controlled, with the rod pressing on the chrome-plated metal sheet. (It is necessary, of course, to provide the compartment with an amount of refrigeration that will not only maintain the minimum temperature called for but will also lower the compartment temperature as rapidly as any particular portion of the chart may require.) The relay is of such a type that the switch controlling the heat is on when the contact point is on the lacquered surface. When the temperature of the Bourdon tube rises, the point ultimately makes contact with the chromium, and the heat is turned off; when the temperature of the tube falls, the point moves back onto the lacquer, and the heat is again turned on. Thus, as the clock revolves, the brush tends to follow the upper margin of the lacquer. This principle of operation eliminates the cam and rider used in other devices. Consequently the amount of heat or refrigeration applied is the only limitation on the speed with which the temperature may be made to change.

In figure 1 is shown an example of the performance of the instrument. Temperatures recorded on a chart taken from the weather records of the Whittier, Calif., laboratory were reproduced. In this test a rather poorly insulated cabinet was used in a room which was held at 41° F.

Although this apparatus was devised to reproduce variable temperature, tests have indicated that it will also lend itself to the reproduction of fluctuating humidity.[1] When used as a thermostat, the instrument has been found to operate at relative humidities up to 90 per cent. It is probable that performance would be satisfactory at even higher humidities. —7-8-44.

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[1] For more than 4 years the Division of Fruitfly Investigations has used a hygrograph in a similar manner, but in conjunction with an electronic relay, to control humidity. In order to prevent current leakage across the insulation when the humidity was high, the hair element alone was installed within the cabinet, while the electrical contact on the hygrograph, which was outside, was operated by remote control.

An Anomalous *Anopheles quadrimaculatus* Larva from Louisiana

WILLIAM F. BUREN, *Assistant Sanitarian (R) Office of Malaria Control in War Areas U. S. Public Health Service*

The occurrence of occasional variations in the shape and size of the hairs or bristles of anopheline larvae, which require that they be reared to the adult stage for specific identification, is well known to all who have worked with these insects. One such instance of atypical form in *Anopheles quadrimaculatus* which came to the attention of the writer is believed to be of sufficient interest to merit recording. The larva is described as follows:

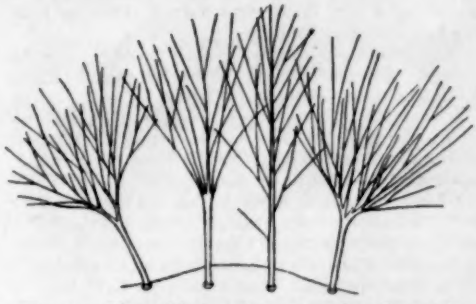

FIG. 1.—Clypeal hairs of an anomalous larva of *anopheles quadrimaculatus.*

Inner clypeal hairs densely plumose for most of their length, the branches often forked, their bases widely set, being as close to the outer clypeal hairs as to each other (Fig. 1). Hair 2 double on abdominal segments 4 and 5. Hair 1 of prothorax with a few branches from near the middle. All the hairs of the body including the brushes of the anal segment tend to be somewhat longer and more branching than in a typical larva. The lateral hairs (hair 6) of abdominal segments 4 and 5, for instance, are 7- and 4-branched, respectively, rather than 4- and 3-branched. In addition the specimen is asymmetrical as there is an extra occipital hair behind left occipital hair 9. Other characters as in typical *Anopheles quadrimaculatus.*

The reared adult, a typical female *Anopheles quadrimaculatus,* and the fourth instar larval skin are in the Louisiana State MCWA collection. The larva was collected by John H. Blake, Engineering Aide, at Pineville, Louisiana, February, 1944.—7-13-44.

Additional Species of Mosquitoes Found in Texas

KELLIE O'NEILL, *Bureau of Laboratories, Texas State Health Department*

L. J. OGDEN AND DON E. EYLES, *U. S. Public Health Service, Malaria Control in War Areas*

Mosquito collections in Texas during 1943 and the first half of 1944 by members of the State Health Department Laboratories and U. S. Public Health Service Malaria Control in War Areas personnel have contributed a number of additional species to the list published in 1943 (McGregor & Eads). These species are as follows:

Aëdes canadensis (Theob.) Larvae and adults collected by Ben M. Duncan in Texarkana, Bowie County, February 1943, examined by T. E. McNeel and E. J. Gerberg. Female collected by J. L. Pate in Houston, Harris County, March 25, 1944, from a light trap.

Aëdes dorsalis (Meig.) Larvae collected by L. J. Ogden in Chicago, E. Paso County, September 27, 1943, reared in the laboratory and determined by Alan Stone.

Anopheles crucians bradleyi King. Reared from larvae collected in Brownsville, Cameron County, March 10, 1944, by T. M. Burns, and examined by G. H. Bradley. Adults identified by N. M. Randolph from light trap collection from Camp Wallace, Galveston County, March 28, 1944. An earlier collection identified by G. C. Menzies from larvae collected by J. D. Weatherby July 1, 1943 in Port Neches, Jefferson County.

Anopheles maculipennis freeborni Aitken. Larvae collected and reared by C. W. Gerber near El Paso, El Paso County, October 19, 1943.

Anopheles walkeri Theob. Adults identified by F. E. Redding and Don E. Eyles from a light trap collection from Orange, Orange County, June 16, 1943, and determined by Alan Stone.

Culex interrogator D. & K. Larvae identified by D. C. Thurman from a collection by D. C. Pfeifer at Harlingen, Cameron County, October 4, 1943. A separate note is being published on this species by D. C. Thurman, L. J. Ogden and Don E. Eyles.

Culiseta incidens (Thoms.) A single female identified by L. J. Ogden from a light trap collection by W. Wray Jonz in El Paso, El Paso County, October 14, 1943, and determined by Alan Stone. Females subsequently collected by Mr. Jonz from the same trap March 29, 1944, and April 20, 1944.

Culiseta melanura (Coq.) Adults identified by Don E. Eyles from a light trap collection from Marshall, Harrison County, July 20, 1943, and determined by Alan Stone.

Psorophora varipes (Coq.) Female collected by Ben M. Duncan from Texarkana, Bowie County, in a light trap May 25, 1943. Female collected while biting by L. J. Ogden, Houston, Harris County, August 6, 1943, and determined by G. H. Bradley.

Appreciation is expressed to Dr. Alan Stone of the U. S. National Museum; Dr. C. W. Gerber, County Health Officer, Las Cruces, New Mexico; Mr. G. H. Bradley, Mr. T. E. McNeel, and Mr. E. J. Gerberg, U. S. Public Health Service, Malaria Control in War Areas, for their help in making the determinations.—7-22-44.

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Tests with Synergists for Pyrethrum Against the Body Louse[1]

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In research on louse powders for the armed forces, the results obtained during the first few months indicated that a powder containing pyrethrum would be effective. Since synergists for pyrethrum had been successfully employed in fly sprays, attempts were made to find an effective synergist for pyrethrum against the body louse, *Pediculus humanus corporis* Deg. The first materials selected for testing were sesame oil, *D. H. S. Activator* (ethylene glycol ether of pinene), and *IN-930*(N-isobutylundecylenamide), which are used for this purpose in fly sprays. In the course of the work more than 200 compounds have been tried, but this paper deals only with these three and illustrates the method of testing the synergistic effect of materials against the body louse.

METHODS AND MATERIALS.—The arm-and-leg method of testing louse treatments, as described by Bushland *et al.* (1944), was used in these tests. For each test the inner surface of a sleeve made of heavy cotton underwear cloth was coated with 3.0 grams of a pyrophyllite powder containing the desired amounts of toxicant and the synergist. The powders were prepared by mixing acetone solutions of the active ingredients with pyrophyllite, evaporating the solvent, and regrinding on a glass plate.

The treated sleeves were placed on the arms and legs of research subjects, 25 young adult lice were introduced in each, and the garments were then fastened to the skin with adhesive tape. They were removed after 24 hours and the surviving lice examined.

Table 1.—Comparison of *IN-930, D.H.S. Activator*, and sesame oil as synergists for pyrethrum (pyrethrins 0.25 per cent) in louse powders. Concentration of synergist 2.0 per cent.

SYNERGIST	TESTS	LICE SURVIVING TREATMENT
	Number	*Per Cent*
IN-930	12	0
D.H.S. Activator	12	6
Sesame oil	8	6
Control (0.25% of pyrethrins without synergist)	12	32

RESULTS.—Bushland *et al.* (1944) showed that by this method a pyrophyllite powder containing 1.0 per cent of pyrethrins was completely lethal to body lice, and that 0.5 per cent gave an average kill of 97.4 per cent, but that 0.25 per cent consistently allowed a considerable number of survivors. The lowest concentration of pyrethrins was therefore used in combination with 2.0 per cent of the material being tested as a synergist. Results of these tests

[1] This work was done under a transfer of funds recommended by the Committee on Medical Research, from the Office of Scientific Research and Development to the Bureau of Entomology and Plant Quarantine.

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are given in table 1. All three synergists were found to be nontoxic to lice at 2.0 per cent in pyrophyllite when tested by this method.

Although synergism was indicated for all three materials, further efforts were concentrated on *IN-930*, since it gave the best results.

Powders containing 2.0 per cent of *IN-930* and 0.01 per cent or more of pyrethrins were found to be completely lethal to lice. No tests were made with higher concentrations of *IN-930*, since it, like pyrethrum extract, is a liquid, and too much liquid impaired the dusting qualities of the powder.

To obtain an estimate of the extent to which *IN-930* increased the initial toxicity of the pyrethrins, 0.005 per cent of pyrethrins was used in combination with 0.25, 0.5, 1.0, and 2.0 per cent of *IN-930*. Comparative tests made with eight freshly prepared powders of each concentration gave, respectively, 32.0, 28.0, 11.5, and 3.5 per cent of surviors, and the lice surviving the last treatment were affected. Although these figures do not represent the average of all the tests conducted, they are considered typical. For instance, 0.005 per cent of pyrethrins plus 2.0 per cent of *IN-930* have in a number of tests given complete kill of lice.

Two per cent of *IN-930* in combination with 0.01 per cent of pyrethrins or 1.0 per cent of pyrethrins alone was completely lethal to lice. It can be seen from the figures above that 0.005 per cent of pyrethrins in combination with 2.0 per cent of *IN-930* allowed a small number of survivors. Since in 14 other tests 0.5 per cent of pyrethrins without a synergist allowed a similar percentage of survivors (2.6 per cent), it appeared that 2.0 per cent of *IN-930* increased the initial toxicity of the pyrethrins about 100 times.

In arm-and-leg tests of powders containing 1.0 per cent of pyrethrins, the treated sleeves remained lethal to lice introduced through 4 days wearing. Although the duration of effectiveness of pyrethrum treatments was not prolonged by synergists to the same extent that the initial toxicity was increased, the protective value of pyrethrins was increased sufficiently so that powders containing only 0.2 per cent of pyrethrins and 2.0 per cent of *IN-930* remained effective for at least 8 days' wearing. It was on the basis of this increased lousicidal value of pyrethrins by the synergist that the MYL louse powder was developed by Bushland *et al.* (1944).[1]

Of the 200 or more compounds tested as synergists, 16 appeared to increase the initial toxicity of pyrethrum to an extent approaching that of *IN-930*. However, when the combination of 2.0 per cent of synergist and 0.2 per cent of pyrethrin was tested for duration of effectiveness, only one other compound appeared equal to it. The results with the other materials will be discussed in subsequent papers.

SUMMARY.—Three materials commonly employed to increase the toxicity of pyrethrum fly sprays were among the 200 or more materials tested as synergists in pyrethrum-pyrophyllite powders against the body louse by the arm-and-leg method.

Sesame oil and *D. H. S. Activator* (ethylene glycol ether of pinene) were found to increase the toxicity of pyrethrins against the body louse, but both were inferior to *IN-930* (N-isobutylundecylenamide).

Although not toxic to lice, *IN-930* was found to increase the initial toxicity of pyrethrins about 100 times.

Pyrophyllite powder containing 1.0 per cent of pyrethrins alone was effective against lice for 4 days, whereas powder containing only 0.2 per cent of pyrethrins in combination with 2.0 per cent of *IN-930* remained effective for 8 days.—7-25-44.

[1] Bushland, R. C., L. C. McAlister, Jr., G. W. Eddy, H. A. Jones, and E. F. Knipling, 1944. Development of a powder treatment for the control of lice attacking man. Jour. Parasitol. (Not yet published.)

Residual Toxicity of Sulfur to the Potato Psyllid in Greenhouses[1]

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Tests were conducted in the greenhouse at Lincoln during the winter months of 1941 and 1942 to determine the residual toxicity of sulfur to the potato psyllid, *Paratrioza cockerelli* (Sulc). Although the potato psyllid does not occur in destructive numbers each year in Nebraska, it is a constant threat and growers more or less regularly apply sulfur sprays or dusts as a protective measure. In view of this fact residual activity of sulfur is important in determining time and frequency of application.

PROCEDURE. The forms of sulfur used were: liquid lime-sulfur, testing 33 degrees Baumé, applied at a dilution of 1 gallon to 40 gallons of water; wettable sulfur, 1 pound to 9 gallons of water; and 325-mesh dusting sulfur. All were applied by means of small hand-operated apparatus at rates roughly equivalent to that used in the field, about 100 gallons per acre for sprays and 30 to 40 pounds per acre for dusts.

Records were obtained on eggs and 3rd, 4th and 5th instar nymphs. The test insects were released into special cages which covered individual potato leaves. The cages were made of cellulose acetate with an opening in one end covered with cheesecloth and a cheesecloth sleeve at the other end for fastening around the leaf petiole. This permitted the cage to be tightly closed and at the same time provided for aeration. Partial shading prevented moisture-condensation inside the cage during periods of bright sunlight. Adults were confined on potato foliage for a given period of time and any eggs deposited kept under observation until they had either hatched or shown definite signs of being non-viable. Nymphs remained on the plant under observation until they had either died or transformed to adults. All tests were accompanied by controls.

Nymphs were confined on potato foliage at varying intervals following treatment of the plant with sulfur. In a limited number of tests nymphs were caged on plants which after being treated with sulfur were washed by means of a sprinkler attached to a water hose[2] to determine the effect of weathering on residual toxicity. Tests also were conducted to determine if there was any translocation of toxicity from treated to untreated portions of the same plant and to foliage developing subsequent to treatment.

RESULTS. Relatively few eggs were laid by females confined on foliage during the first four or five days after treatment of the plants. Following this period, there was an increasing number of eggs, but no normal individuals developed from eggs deposited until the precaging interval[3] exceeded 12 days. Many of the eggs became badly shriveled within a few days after deposition without showing

[1] Published with the approval of the Director as Paper No. 259, Journal Series, Nebraska Agricultural Experiment Station.

[2] Equivalent to about 0.5 inch of rain.

[3] "Precaging interval" is the period between treatment of a plant and confinement of insects on the plant.

andy signs of development; others developed but the nymphs died before escaping from the egg-shell. In three series of tests where the precaging interval was 14 days, a comparatively large number of eggs were deposited, but only a small proportion hatched normally. Approximately normal deposition and hatching occurred in two series where the precaging interval was 19 days and 25 days, respectively. In all cases development in the controls appeared to be normal.

Data on the residual toxicity of liquid lime-sulfur, wettable sulfur and dusting sulfur to *Paratrioza cockerelli* nymphs show that in 11 tests with liquid lime-sulfur, in which precaging intervals were from 6 to 39 days, only 4 normal adults emerged; in 12 with wettable sulfur having precaging intervals of from 1 to 36 days, no normal adults emerged, and in 9 with dusting sulfur having precaging intervals of from 6 to 39 days, only 10 normal adults developed. As would be expected, the rate of lethal action and final mortality decreased as the precaging interval increased. Considerable numbers of nymphs in the longer interval groups completed nymphal development but died while transforming to the adult stage. Others emerged but in an apparently deformed state, the wings usually failing to unfold properly. Development in the controls was normal.

At intervals following treatment with sulfur a series of plants were exposed to artificial rain (about 0.5 inch) and immediately afterwards 20 nymphs were confined on them: In four tests, with liquid lime-sulfur having prewashing[1]-precaging intervals of 1 to 12 days and in 2 tests with dusting sulfur at 5 and 12 day intervals, only 8 of the 120 nymphs used developed into normal adults; in five tests with wettable sulfur the intervals varied from 5 to 21 days and only 13 out of 100 nymphs developed into adults.

In three tests, all of the foliage on a plant except one leaf was sprayed with liquid lime-sulfur and then after a 10-day interval 20 nymphs were confined on the untreated portion. All of these developed normally, depositing eggs which hatched. None of the insects in controls confined on the treated foliage of the same plant developed normally. Twenty nymphs were confined in each of three other tests on foliage developing subsequent to treatment; again normal development occurred in contrast to a failure to develop in controls on the treated foliage. It seems likely, however, that the protective value of sulfur sprays and dusts is not greatly affected by this fact since psyllids feed largely on the more mature leaves.

In 10 tests involving 20 nymphs each, leaflets were thoroughly covered with liquid lime-sulfur on one surface and then the insects caged on the other side. Normal development occurred in all cases, a result which emphasizes the desirability of securing thorough coverage of foliage.

SUMMARY. Potato plants treated with either liquid lime- wettable- or dusting sulfur remained toxic to *Paratrioza cockerelli* for 4 or 5 weeks under greenhouse conditions.

Normal psyllid development occurred on potato foliage which appeared subsequent to treatment with sulfur indicating that there is no translocation of toxicity from treated to untreated portions of a plant.

Application of sulfur to one surface of a leaf did not induce toxicity on the opposite surface.—7-14-44.

[1] "Prewashing interval" as used here refers to the period between treatment and exposure of plant to "artificial rain."

The Toxicity of DDT to *Adoretus sinicus* in Hawaii[1]

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The Chinese rose beetle, *Adoretus sinicus* Burmeister, family Scarabaeidae, is the most important foliage-consuming insect of green beans in Hawaii. The adults feed on the foliage at night, and, when abundant, skeletonize the leaves.

Field techniques for studying materials to control the beetle proved to be unpromising, so a cage technique has been developed by which the toxicity of materials to the beetle could be measured quantitatively. Until recently, the toxicity of forty materials or mixtures had been tested. Of these materials, acid lead arsenate had been found to be the only insecticide with marked toxicity to the beetle; acid lead arsenate with astringent[2] is somewhat more toxic than standard lead arsenate. Because acid lead arsenate commonly causes injury to the foliage of bean plants no really satisfactory material has been available for controlling the beetle.

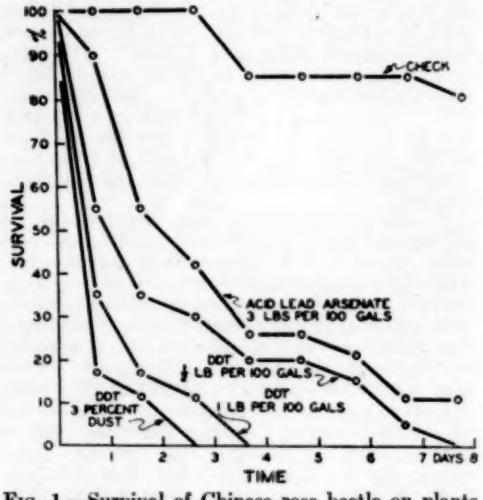

FIG. 1.—Survival of Chinese rose beetle on plants treated with DDT and with lead arsenate.

Dichloro diphenyl trichlorethane, DDT, has now been found to be much more toxic to the beetle than acid lead arsenate. While many aspects of the use of DDT for control of Chinese rose beetle remain to be studied, the early results are so outstanding as to warrant brief mention at this time.

In a study involving a 3 per cent dust[3] and sprays[4] containing quantities of the active agent equivalent to from 2 ounces per 100 gallons to 1 pound per 100 gallons, the following results have been secured.

With the 3 per cent dust mortality after 1 night's exposure was 82 per cent, and 100 per cent after 3 nights' exposure; 50 per cent mortality was secured

[1] Published with the approval of the Director as Technical Paper No. 119 of the Hawaii Agricultural Experiment Station.

[2] Prepared and supplied by the General Chemical Company.

[3] *Gesarol AX* dust applied by the Geigy Company Incorporated.

[4] Prepared from *Gesarol AKD 20* spray containing 20 per cent active agent together with a wetting agent.

in approximately 11 hours. With a spray of 1 pound of active ingredient per 100 gallons, mortality was 65 per cent after 1 night's exposure and 100 per cent after 4 nights' exposure; 50 per cent mortality was secured in approximately 13 hours (Fig. 1).

After exposure for one night, mortality with a spray containing 2 ounces of active ingredient per 100 gallons, was twice as great as that secured with a spray containing 4 pounds of standard acid lead arsenate per 100 gallons. In a similar period of time, mortality with a spray containing 4 ounces of active agent per 100 gallons was several times greater than the mortality with the lead arsenate spray. (Forty per cent with the DDT against 5 per cent with the lead arsenate.) After a further period of 24 hours, mortality with the lead arsenate increased and, at the end of 3 nights had exceeded the mortality with DDT 4 ounces per 100 gallons. (Sixty-eight per cent with lead arsenate and 50 per cent with DDT.) Fifty per cent mortality was secured with 4 pounds of standard lead arsenate in approximately 51 hours.

With 3 pounds a standard acid lead arsenate per 100 gallons, mortality was 10 per cent after exposure for 1 night and 89 per cent after exposure for 8 nights; 50 per cent mortality was secured in approximately 48 hours.

Mortality in the check was nil for 3 days and only 20 per cent at the end of 8 days.

FIG. 2.—Plant treated with 2 per cent DDT (left), and untreated plant (right). Both plants were caged for 8 nights with 40 Chinese rose beetles.

With the 3 per cent dust, plant injury from the beetle was barely measurable; there were four tiny holes equal to a total of 4.6 sq.mm. of leaf surface consumed by 20 beetles. With sprays of relatively high concentration (12 and 16 ounces per 100 gallons) foliage injury caused by beetles was slightly greater than that with the 3 per cent dust but still insignificant. Foliage injury from the beetles was somewhat more but still slight with the smallest concentration of DDT (2 ounces per 100 gallons). The injury caused by the beetles to the foliage of the check plant was severe; many of the leaves were in a ragged condition with more than three-fourths of the leaf tissue gone. Approximately half the leaf tissue of the plant was consumed in 8 nights.

In a second study sprays ranging in concentration from 4 ounces to 1 pound of active agent per 100 gallons were studied again, and, in addition, dusts ranging from 0.25 per cent to 3 per cent of the active agent. These dusts were made from the 3 per cent dust by diluting with talc. Results secured in the second study are essentially similar, with slight variation, to those obtained in the first study.

The following additional information on the toxicity of dusts has been secured. Mortality is apparently higher with a 2 per cent dust than with a 3 per cent dust. Mortality with a 1 per cent dust is almost as high as that with a 3 per cent dust. A dust of 0.5 per cent concentration is equivalent in toxicity to a spray of concentration 8 to 12 ounces per 100 gallons and only slightly less toxic than 3 pounds of lead arsenate with astringent per 100 gallons. A dust of 0.25 per cent is comparable in toxicity to a spray of 4 ounces per 100 gallons.

Many of the beetles confined for one night with plants treated with DDT are unable to crawl into the soil after they leave the plant; some are dead on the surface of the soil. In one replicate of plants treated with 2 per cent dust, 31 beetles out of 40 or 77 per cent were on the surface of the soil the following morning; 24 of these or 60 per cent were dead. In another replicate 36 beetles out of 40 or 90 per cent were on the surface of the soil; 30 of these or 75 per cent were dead.

Fifteen out of 36 beetles, confined overnight in an otherwise empty cage dusted with 2 per cent DDT dust were dead the following morning. Those still alive were then placed in a clean cage with a clean plant for food. A total of thirty-one were dead by the second day, 33 by the third day and all were dead after 8 nights. Practically no feeding took place on the plant provided for food.

Only 1 beetle of a similar group introduced into a similar cage dusted with 33.3 per cent acid lead arsenate was dead after 1 night. The living beetles were then placed in a clean cage with a clean plant for food as were the beetles which had been confined in the cage dusted with DDT. By the second day 4 were dead and after 8 nights, when all from the cage dusted with DDT were dead, only 5 of those submitted to the lead arsenate were dead. A considerable amount of foliage was consumed by this group of beetles in contrast to almost none consumed by the beetles submitted to DDT.

From the studies to date, it is concluded that DDT dusts of concentration 1 to 2 per cent and sprays of concentration 8 ounces to 1 pound per 100 gallons give excellent control of Chinese rose beetle. The data suggest that practical control may be secured with dusts or sprays of lower concentrations than those mentioned.

In preliminary studies on the effect of DDT dusts on the foliage of green bean plants in the field some foliage injury from the insecticide has been observed with the 3 per cent dust when the plants were wet when dusted and the application heavy. None has been observed with a 2 per cent dust, a 1 per cent dust, or sprays of 2 pounds and 1 pound per 100 gallons. The cage studies indicate that 3 per cent is unnecessarily strong to effect good control.

Thus the evidence points strongly to the conclusion that a satisfactory control for Chinese rose beetle has been found in DDT.—7-24-44.

Obtaining Eggs of the Potato Tuber Worm for Use in the Mass Breeding of *Macrocentrus ancylivorus*

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In the mass breeding of the oriental fruit moth parasite *Macrocentrus ancylivorus* Roh. on potato tuber worms there are certain advantages in stocking trays of potatoes, in which the parasites are to be reared, with eggs rather than with moths of the host species, *Gnorimoschema operculella* (Zell.). These advantages include a closer control of the age of the host larvae at the time they are exposed to parasite attack, which is of importance in facilitating parasitization; reduction by 3 or more days in the length of time each tray is in use, depending upon the incubation period of the tuber worm eggs; and the elimination of certain objectionable features such as moth debris and scales.

It was found that the presence of potato or other natural food is not necessary to stimulate oviposition and that the host eggs are not laid freely on smooth surfaces such as leaves or paper in oviposition cages. The moths prefer to oviposit in small crevices, and owing to the soft adhesive material on the chorion, the eggs cannot be handled like those of *Sitotroga* and *Tribolium*.

FIG. 1.—Eggs of the potato tuber worm laid on brownprint paper.

The following technique for obtaining eggs of the potato tuber worm has been worked out at the laboratory of the Bureau of Entomology and Plant Quarantine at Moorestown, N. J.: A cage measuring 6 by 8 by 12 inches and covered with 20-mesh wire screen, which is fine enough to prevent moths from escaping, is set up on wet sand. About 3000 moths are liberated in each cage, and oviposition takes place through the top of the cage and through a fine-mesh paraffined screen mat onto paper laid upon it. A 60-mesh wire cloth has been found ideal for the mat, as moths oviposit through it readily, laying only 1 egg per mesh. This mat is prepared by dipping it in hot paraffin and blowing the excess paraffin out of the meshes with compressed air. This treatment prevents the eggs from adhering to it. Eggs have been obtained in large numbers on paper toweling, mimeograph paper, and brownprint paper. The brownprint paper has been the most satisfactory, as moths appear to oviposit on it more readily than on other materials, and when it is ruled with small squares its use facilitates counting or estimating the eggs (Fig. 1). Brownprint paper can be printed by contact in large sheets and cut into pieces the size of the fine-mesh mat. The mat and then the paper are placed on the top screen of the cage and are pressed uniformly against it by a sand bag which is lightly tamped in place to insure uniform contact of the paper and mat against the top screen of the cage. Each paper is exposed to the moths for 24 hours. Moths produce eggs in large numbers for about a week. When the daily production drops to a comparatively small number the cages are cleaned and restocked.

By this method 15 to 20 eggs are obtained for each moth used. One cage containing 3600 moths produced an estimated 19,000 eggs during a single night and 71,000 in a 9-day period. The location of the cage may influence oviposition. While the effects of individual environmental factors have not been studied, it is suspected that high humidities are unfavorable for egg laying.—7-10-44.

[1] The author expresses his gratitude to H. W. Allen and W. P. Yetter, Jr., for their assistance and suggestions, and especially to the latter for the photograph.

Residual Effect of DDT Sprays on Early Spring Apple Aphids

L. F. STEINER, *U. S. D. A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

In experimental plots at Vincennes, Ind., in which tests of DDT (2,2-bis(parachlorophenyl)-1,1,1-trichloroethane) were conducted against the codling moth, *Carpocapsa pomonella* (L.), in 1943 (Steiner *et al.*, 1944), it became apparent in the spring of 1944 that very striking reductions in aphid infestation had been effected by this insecticide. Because of the widespread interest in DDT, these observations on aphid populations of trees sprayed in 1943 are reported here.

Apple buds on from 1 to 3 trees in each of several plots were examined between April 8 and 12, 1944. The buds were in the late pre-pink stage of development, and the hatching of the aphids was practically complete. In the heavily infested trees as many as 40 aphids were counted on one bud, while on the lightly infested trees the number seldom exceeded 5.

The apple grain aphid, *Rhopalosiphum prunifoliae* (Fitch), constituted more than 99 per cent of the population. The rosy apple aphid, *Anuraphis roseus* Baker, was more generally present than the apple aphid, *Aphis pomi* Deg. Only the apple grain aphid was observed on those plots having less than 10 per cent of infested buds. This species began hatching March 15, whereas the rosy apple aphid was first found on March 27. The infestation data are given in table 1.

The lowest aphid populations in each series of tests were associated with the DDT treatments that gave the best control of the codling moth. The length of time between the last spray and the return of the fall migrants to apples was also a factor. More aphids were present on buds in the tops of DDT-sprayed trees than in lower sections, while little difference was noted on other trees. These facts suggest that the amount of DDT deposit remaining on the foliage and wood of the new fruit spurs when the aphids begin ovipositing determines the extent of oviposition. It must also be recognized that the deposit may have been repellent rather than toxic to the females. No eggs were found on the DDT plots, but most of the shells on the other plots had sloughed off.

Table 1.—Early-spring aphid infestation of buds on apple trees sprayed with DDT in 1943. April 8–12, 1944.

EXPERIMENTAL SPRAY TREATMENT[1] (QUANTITIES ARE FOR 100 GALS. OF SPRAY)	BUDS INFESTED WITH APHIDS
	Per Cent
Commercial Winesap orchard given 6 cover sprays of lead arsenate prior to 3 experimental sprays July 22, Aug. 12 and 28 (200 buds examined per plot):[2]	
DDT-pyrophyllite[3] 1.5 lbs.	7
DDT-pyrophyllite 3 lbs.	0
Lead arsenate	68
Nicotine bentonite	78
Experimental Winesap plots; 4 sprays, final spray Aug. 14 (100 buds examined per plot):	
DDT 1 lb.	22
DDT 1 lb. plus emulsive-type oil 0.5%	27
DDT 1 lb. plus bordeaux ($\frac{3}{4}$:1$\frac{1}{4}$:100)	41
Lead arsenate	65
Unsprayed	67
Experimental Grimes Golden plots; final spray Aug. 12 (300 buds examined per plot):	
Nicotine bentonite (2 sprays), DDT 1.5 to 2 lbs. (3 sprays), DDT-pyrophyllite 2 lbs. (2 sprays)	0
Lead arsenate (4 sprays), DDT 2 lbs. (3 sprays)	5
Tank-mix nicotine bentonite (4 sprays), DDT-pyrophyllite 2 lbs. (3 sprays)	3
DDT 1 lb. (2 sprays, last on July 21)	21
Lead arsenate (7 sprays)	79
Nicotine bentonite (7 sprays)	91
Unsprayed	91

[1] All lead arsenate and nicotine bentonite sprays were applied at the usual recommended strengths.
[2] Details of treatments given by Steiner *et al.* (1944).
[3] All DDT-pyrophyllite mixtures were 50:50.

No outbreak of aphids occurred among these plots in 1943; hence the effect of DDT on this insect was not observed at that time. However, by applying a 10 per cent DDT dust to infested branches the writer has obtained a knockdown of most aphids present within 2 hours.

Although the results warrant more extensive investigation of DDT for combined codling moth and aphid control, it must be recognized that the high toxicity of DDT to certain parasites and predators may result in unsatisfactory control of aphids if the tremendous aid given by these natural enemies is removed.—7-2-44.

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Etherization and Refrigeration for Shipment of Insects

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An important phase of the biological control of the Oriental Fruit Moth has been the transportation of the parasite *Macrocentrus ancylivorus* from the insectary to the orchards, often over distances of several hundred miles.

In our work in California we began by shipping tuber moth cocoons bearing the cocoons of the parasite. This method had no particular faults excepting that it is very difficult to avoid sending out a few unparasitized cocoons, along with the many parasitized ones. Since the tuber moth is wide-spread in California, no real harm results from this practice, but it is better to avoid the shipment of pests if for no reason other than that it may be misunderstood by some orchardists. So we have undertaken to develop a satisfactory method of shipping adult parasites only.

The method heretofore used in the eastern states, that is, the shipment of about 500 adult parasites in unit containers of about 100 cu. in. capacity, sent either by air or by use of refrigerated ice-cream tubs (Allen *et al.*, 1940) is not practical on the scale of operations now in effect. We are now shipping more than a quarter of a million *Macrocentrus* daily, and the large number of containers required would make this method practically out of the question. Also the daily collection of this number of adults by the aspirator method, to say nothing of the screen area required by so many parasites, was an added inducement for development of another and simpler technique.

For several months now we have handled the adult tuber moths very successfully by the use of etherization. Ether was also tried on the parasite and proved to be equally satisfactory, and it is now possible to etherize daily the cabinets in which the sheets bearing parasitized cocoons are held, for the collection of both adult moths and adult parasites. This solved the problem of collection of parasites, but did not eliminate the difficulties created by the number of shipping containers required and the great bulk of the shipments. It is not possible, of course, to hold the parasites under anesthesia for more than a few minutes. However, a test was made involving the holding of 2500 anesthetized *Macrocentrus* under refrigeration, and after a period of four days these previously anesthetized, and then refrigerated, parasites recovered perfectly. It is now our plan to utilize this principle for shipment of adult parasites to the orchards.

It was at first thought that the parasites could be shipped in vacuum bottles. Tests indicated, however, that it is difficult to maintain a sufficiently low temperature in ordinary vacuum bottles to prevent the adults from becoming active and injuring themselves, over the period of 48 hours thought necessary as a safety factor. A small insulated shipping unit is being developed which, by utilization of ice, will keep the parasites quiescent for the necessary length of time. An ordinary plastic tube two by three-fourths inches in size will hold roughly 2000 adult parasites, packed solid.—7-11-44

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Pyrethrum Marc[1] for Control of Fall Cankerworm and Tussock Moth

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During the present season when no pyrethrum concentrate was available to make the customary commercial sprays used in the control of cankerworm and tussock moth, field tests were made with pyrethrum marc containing approximately 0.03 per cent pyrethrins. The applications for the control of fall cankerworm on apricots gave excellent results with pyrethrum marc at four pounds with four ounces sodium laurel sulphate spreader per hundred gallons or with a commercial product made from marc and containing pyrethrins 0.03 per cent, petroleum oils 5.0 per cent, and methyl naphthalene 16.0 per cent. Over 600 acres of apricots were sprayed commercially with the proprietory product with most satisfactory results. In the control of tussock moth the same commercial product effectively controlled the larvae attacking apples and pears.—5-10-44.

[1] The residue left after the pyrethrum extract has been pressed from pyrethrum flowers.

Leucopoecila albofasciata,[1] a Pest of Golf Greens

A. F. SATTERTHWAIT, *U. S. D. A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

On September 3, 1925, The Midland Valley Golf Club, Overland, St. Louis County, Mo., called for help in the control of an infestation of *Leucopoecila albofasciata* Reut. (det. McAtee) on their Rhode Island bentgrass greens. For the preceding 3 weeks the growth of the grass was only 10 per cent of normal, notwithstanding the fact that the plant food had been doubled and the greens liberally watered. The grass blades were discolored. The greens were examined on September 5 and again on September 19. The species was swarming on the greens and hundreds of specimens were taken. Both adults and nymphs have strongly developed metathoracic jumping legs and when disturbed they quickly dispersed and hid. Though the adults have long wings, they fly only after about the second jump. When the greens manager called for help in the control of this bug, he believed the insect was the chinch bug. Since it proved otherwise, he objected to the application of any insecticide.

Blatchley (1926) reports this insect from Jamaica, Florida, Pennsylvania, and California. Prior to 1926 it was reported by Wirtner (1904) under the name of *Rhinacloa forticornis* Reut. at "Greensburg, Pa., July to September, as common in hay-fields; abundant in fields where the grain has been cut." It was also reported by Van Duzee (1914) that near San Diego, Calif., it was "common in alfalfa fields throughout the year." Van Duzee (1917) in his later catalogue adds nothing to the above record of its distribution. Illingworth (1931) records *Leucopoecila albofasciata* as "an introduced species which breeds in purslane and nightshade, and under certain circumstances will oviposit in the tender pineapple leaves."—7-13-44.

[1] Hemiptera, Miridae.

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The Tomato Russet Mite in Colorado

JOHN L. HOERNER, *Colorado Agricultural Experiment Station, Fort Collins*

In September 1943, mites were found injuring tomatoes in two fields in Mesa County and two fields in Delta County. These mites were determined by H. H. Keifer, Calif. Dept. of Agriculture, as *Phyllocoptes destructor* Keifer. This is the first record of the occurrence of this mite in Colorado.

About 3 acres of plants were killed in one 10-acre field. Straight sulfur dust and 25 per cent sulfur dust were applied to the remaining plants. The dusts appeared to stop the injury immediately. Nine days later crawling mites were seen on the untreated plants while none were observed on the treated plants. At the time the plants were dusted the weather was becoming cool, and probably very little or no additional injury would have occurred.

In checking the source of the plants, no definite information was obtained. Most of the plants used were from the Boulder Dam area; some of the replants were locally grown.—6-2-44.

NOTICE

Annual Meetings of the Association, Hotel New Yorker, N. Y. City, Dec. 13, 14 & 15.

JOURNAL OF ECONOMIC ENTOMOLOGY
Official Organ American Association of Economic Entomologists

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Needed Changes in Teaching Entomology[1]

I SUSPECT most of us feel that certain changes in the methods of teaching entomology would improve the quality of our graduates and higher degree students. Perhaps most teachers in this field feel the need of some improvements along this line. I have felt this need and I daresay that most of you who are sitting before me have somewhat similar reactions; and now that I have an opportunity to speak of these needs, I realize only too well how difficult it is to try to formulate methods for improving the varying procedure that has gradually taken over entomological instruction in this country.

A curriculum may be prescribed. Methods and equipment for teaching may be standardized. Qualifications for a teacher may be imposed. Suitable quarters may be provided. But all of these and many other rules and regulations do not in themselves insure either a good or adequate course in entomology or any other subject taught in our schools.

Teaching is not an exact science. It cannot be prescribed nor can it always be regulated towards efficiency or success. Some have said that a teacher is born to that work and not made! Many who believe this are, nevertheless, extremely poor dispensers of knowledge.

It is not my purpose to delve into the qualifications and personalities of those charged with the responsibilities of training entomologists. As I look back to my own student days it seems to me that my *best* teachers were men enthusiastic about their profession and interested in me. The preciseness of their speech, the exactness of their fund of knowledge, and the greatness of their acclaimed achievements were not the qualities that inspired and disciplined me. Their personalities that touched mine, their interest in me that warmed my heart and stimulated my mind to energy and devotion, their encouragement that enabled me to surmount all difficulties, and their lasting friendship that started me on my highway of life and has kept me going; these qualities and relationships, supported by self discipline, scholastic training, hard work, and a compelling desire to serve, make good teachers.

With such a combination of qualities there is little to fear about the future training of entomologists or any other professional men.

In olden days students sought teachers and not institutions. Today, the well advised seeker of knowledge will select that institution which has well qualified instructors and permits them to teach without imposing too much curricular servitude.

I believe that there is much good teaching of entomology in our institutions today, and there is no doubt that great improvements are constantly being made all along the lines in this field. We must realize that every university or college is a particular distinct unit with a teaching staff that is different from every other group of instructors. Usually, these groups consist of men who have been trained in several different institutions and each of these men is a distinct unit in himself. We might as well realize this situation and know that when we speak of teaching entomology in America, we must think of it as having all of the variety that comes from men trained in the many institutions of higher learning in this country and in many other parts of the world.

There is little or nothing we can do about the personal qualifications of individual teachers. Good teachers must be sought and students might well consider the available instructors as well as the institution. During the past years I have listened to discussions on the improvement of the teaching entomology in our Association meetings, and, in the main, these discussions have mostly centered

[1] Presented as a part of the Program of the Pacific Slope Branch, June 1944.

around the more concrete aspects of the subject such as the adoption of a suitable and up-to-date course of study and the emphasis that should be placed upon the essential fundamentals and a well-balanced economic program. To my mind, matters of this sort have all been fairly well settled, and our curricula are among the finest looking compositions that can be found in a university or college announcement of courses. Every year we ponder over our laboratory and course procedure and there does not seem to be any amount of re-arrangement, additions, or subtractions that afford a remedy to the difficulties that are involved in this subject. It does not seem necessary to throw away our present methods of teaching entomology and related biological subjects with the idea that we are going to replace them with new ways of inducing men to acquire knowledge. Therefore, I have decided to dismiss the general improvement of the curricula and the general field of pedagogy in this brief discussion.

Nevertheless, I believe that one of the most important needs in entomology today is the teaching of more fundamentals in the recognition of insects and in their biology. There has been a definite tendency during the past ten years to neglect the more basic aspects of entomology and to emphasize increasingly the more practical features which have to deal with cotrol measures. This has been largely due to the fact that students have sought out these practical courses in preference to the rather more difficult fields of taxonomy, morphology, and ecology. The preparation for a job and a ready means to a livelihood upon graduation from college have outweighed the desires to get the best possible educational foundation in the more professional aspects of the subject. Then, too, we can never overlook the fact that entomology is a product of the agricultural colleges and experiment stations, and that it is only natural that these institutions should emphasize those more practical aspects that are deemed most helpful to crop production.

Only the well trained professional entomologists are aware of the fundamental needs in the education of a well trained student. The experience that so vitally supports curricular training is clearly important, although it hardly comes within the scope of this paper.

I am not going to attempt even to lay out a formal course of study but I do want to call attention to the fact that the diagnosis of insects and their work is a fundamental need. Therefore, every student should become thoroughly familiar with insect species and their work, and he should be able to lay out a proper procedure for studying the more intricate biology of the particular species involved and to program its control. Naturally, it is impossible during the three or four-year period that a student is in college for him to be able to know all of the common insects even in a single area, let alone all of those that are likely to occur within the boundaries of a state or a nation. To meet these varying needs it is necessary for the student to be able to work with keys for the determination of the various categories of insects and to become sufficiently familiar with the literature so that he may know how and where to look for the information that may be needed in each particular case or problem. I doubt if very many entomologists are aware of the extent and wealth of entomological literature. The amount is so appalling that most students are willing to dismiss the entire matter with the idea that it is impossible for him to ever acquire an adequate personal library. Unfortunately, this is one of the great mistakes that most professional entomologists make. A doctor, a lawyer, a musician, an artist, or any other professional person, is wholly at sea and incapable of very satisfactory original work if he does not possess the tools of his profession. A law library is absolutely indispensable to anyone practicing the profession of law. A doctor without a library and without the instruments that are necessary for his practice must acquire the fundamental works on medicine or surgey as well as those instruments necessary in the general pursuit of his profession while he is still a student in the medical school. In spite of the costs that are involved these students actually do acquire these expensive necessities. In contrast to these professions, students in entomology are woefully lacking in books, instruments, and specimens when they apply for a position.

I have known of men with higher degrees coming to an important permanent position without any of these professional requisities. True, the universities have

libraries and some of them have excellent insect collections and the equipment essential for proper teaching of entomology. But even these do not reconcile this dearth of professional equipment with the idea of a well trained professional man. It may be that this lack of personal sacrifice in providing for such facilities is an indication of the present lack of interest, enthusiasm, and efficiency of so many of our present day entomological teachers.

As I have already said, an instructor must have more than a mere education to train students, and I am more than emphatic in calling this situation to the attention of all men who are given the responsibility of educating students so that they may successfully meet the intricate and ever increasing problems in entomology. Never before in the history of man have there arisen so many difficult situations that require thorough training, abundant facilities, and clear thinking.

Professor C. F. Baker, under whom I had the pleasure of spending many profitable student days, frequently repeated the statement that no man could direct a work that he could not himself do. He used this phrase to instill into the minds of every student the idea that from the beginning he must make up his mind to work and to be sure that every phase of entomology should be mastered in order that in after years important problems might be undertaken and all important projects properly supervised and directed.

I have not said very much about what should be taught. I have said nothing as to the number of hours that should be given to this problem or to that laboratory period. My whole emphasis has been on the teacher rather than on the curriculum. I might have summed up all I have to say at the beginning with a statement that if you wish to do a good job of spraying you should buy a good rig. If you are thinking of improving the teaching of entomology, you should employ good teachers.

Those who have what may be called advanced ideas in nomenclature, in the interpretation of historical events, and in organization, and publish them should not fail to realize that more than a considerable amount of opposition is sure to develop among the older and more established members of our profession. The appearance of any publications that seem to be out of line with the accepted and standardized ideas, are almost always in for a lot of criticism, much of which has no real justification. Therefore, it must be admitted that the older ideas are sure to proceed in the minds of many as long as they are alive. It remains for the next generation to take up these new ideas. The young men and the young women who succeed us are our hope for advancements. To them we may trust our cherished ideas, knowing full well that they will not be hampered by the same circumscribed rules and regulations that bound so many of us in our more mature years. It is to them that we may entrust new ideas and it is to them that we may hope for change and advancement in our profession.

E. O. ESSIG

An Educational Approach Toward the Revision of Service Courses in Economic Entomology

THE IMPORTANCE of reviewing various fields of entomological endeavor in order to formulate programs in keeping with postwar objectives has been emphasized in recent editorials (April and August 1942). Thus far little discussion has been devoted to the probable postwar needs in the teaching field of entomology. The fact that decreasing numbers of regulary enrolled students are receiving formal instruction in entomology in colleges and universities and an increasingly large number of enlisted men are being trained in the fields of sanitary and medical entomology in various branches of our armed forces suggests that there will probably be a need for certain postwar curricular readjustments to include such wartime developments as can be incorporated into the teaching practices of normal times. In addition, the social and vocational needs of men and women returning from service will undoubtedly impose new obligations which our institutions of higher learning can supply only through careful surveys for the purpose of deter-

mining the appropriate objectives and insuring their proper relationship to teaching materials.

The immediate need for extensive revision of existing entomology courses seems scarcely imperative, but a thoroughgoing review of introductory courses to decide whether the methods and materials of instruction now used are best adapted for accomplishing those objectives which still seem appropriate, is worthy of consideration. Such analysis, providing it embodies sound educational procedure, will serve to clarify the relationship of objectives and methods, and faculty members participating will be in a position to effect necessary postwar changes with dispatch. It is not the present purpose to discuss the courses designed for the training of professional entomologists, but to call attention to a basic educational procedure which should be valuable in shaping entomology courses to conform to desired objectives, and in selecting methods and materials of instruction so they will be appropriate for achieving these objectives. The examples chosen for illustration refer to the teaching of entomological service courses in an agricultural college but the principle applies equally well to similar courses in other colleges.

It is perhaps an all too common practice to approach the revision of courses and curricula through a detailed reorganization of the body of content whereby the subject matter items are rearranged and classified on the basis of systematic organization of such subject matter in a manner felt to be most teachable. This is illustrated in the varying degrees of emphasis given in textbooks on economic entomology to such commonly recognized subject matter divisions as structure, development, classification, behavior, economic importance and the several types of control practices. In contrast to this is the procedure which recognizes the need for fundamental aims based on the social and vocational requisites of the student and the value of properly relating the immediate teaching objectives and units of instruction to these. This procedure is particularly applicable to our present purpose because it circumscribes the learning activities which contribute toward training in economic entomology within the proper social sphere in which the student may be expected to function later in life, and allows the statement and definition of those larger objectives which are necessary if any course of study is to assume its proper role in the ultimate aim of all educational procedure—efficient participation in life activities.

The broad aim[1] of the four-year curriculum in agriculture, as stated in a "Survey of Land Grant Colleges and Universities" published by the Office of Education of the United States Department of Interior (1930), comprises the training of persons going into farming and related occupations and professions so that they will develop into leaders, and thus contribute to the upbuilding of rural institutions and the improvement of American country life. It is recognized, moreover, that preparing students for general farming is not entirely the primary function of the resident undergraduate work but that, due to certain social, economic and educational advances, certain vocational objectives have become increasingly important, namely the preparing of (1) extension workers to disseminate knowledge concerning the applications of scientific and economic truth to problems of rural life: (2) the preparing of teachers of vocational agriculture and science; (3) of public servants in the investigating and regulatory departments of State and National governments; (4) of research workers in the scientific and social fields related to agriculture and (5) of managers of large-scale farm enterprises, as well as workers in all types of business and commercial activities related to agriculture. From the foregoing it may be seen that the ultimate objective of agricultural education is distinctly cultural and social while the immediate objectives are largely vocational with certain closely related, social implications.

To function effectively in the attaining of these objectives the Entomology Department of the agricultural college should develop aims and objectives which are consistent with these broader ones of the college itself, and primary consideration should be given to those responsibilities assumed in entomological instruction as related to the function of agricultural education. When so conceived, the *broad aim*

[1] The term "broad aim" or ultimate objective is intended as covering large areas of life activities, while the immediate or specific objective represents a more immediate goal which, when accomplished, makes a definite contribution toward the attainment of the ultimate objective or aim.

of the Department is to build in the student a scientific attitude toward and an appreciation and understanding of the field of entomology in relation to agriculture, while the more *specific objectives* include the providing of appropriate learning experiences in such commonly recognized subject matter areas as insect structure and development, classification and relationship, behavior and environmental relationships and economic problems including the development and application of control factors.

Since the attainment of the aims and objectives of the Entomology department is largely dependent upon the courses developed and that of the agricultural college upon their proper organization into curricula a logical relationship of subject matter to objectives should be maintained. Certain techniques described in the Survey previously quoted are helpful in this problem. It is suggested that curricula should not be syntheses built out of courses already offered by the various departments, but rather should grow out of department and inter-department conferences in which common objectives are discussed, clarified, and agreed upon. A census of available materials may then be made and those which indicate promise of being most useful in attaining specified objectives are developed. Finally, all is integrated to fit into a structure of predetermined educational design. Thus the resulting curriculum consists of courses so prepared on the basis of desired outcomes as to harmonize with other similarly prepared courses and it becomes a device for efficient student guidance and training.

Other results of the Survey which are described as "general trends in agricultural curricula since 1880" are suggestive in the organization of introductory courses, *i.e.*, (1) The elimination of foreign language requirements; (2) a reduction in the number of hours in mathematics, physics and chemistry; and (3) the increase of course offerings in economics and free electives, particularly rural sociology, agricultural engineering, agricultural education, and forest, soil and wild-life conservation. The first inference to be drawn is the advisability of eliminating unnecessary technical terminology derived from foreign etymology. The functional content should be taught in simple English, the object being to emphasize in the mind of the student the underlying thoughts and principles, rather than to complicate an otherwise useful and practical subject with an intricate and often empty phraseology. Secondly, beginning courses should contain an adequate introduction to both the facts and methods employed in securing information concerning the economic status of injurious and beneficial forms of insect life, as well as an explanation of their social significance in problems of health and sanitation in rural communities. Third, the attention of the student should be directed toward a realization of the appropriateness and availability of insect material as visual aids in courses in vocational agriculture and in extension teaching and demonstration. Fourth, there should be an emphasis of the rapid progress being made in the fields of mechanical and chemical control without necessarily including the theoretical phases which require an advanced knowledge of chemistry, physics, and mathematics. Some of these implications will merit particular consideration if special courses of a vocational nature are to be offered to students returned for rehabilitation after the war.

When departmental aims and objectives are soundly established these will serve as a guide in the developing of appropriate units of instruction for the courses to be offered. Such units should be in keeping with the objectives of both the agricultural division of the entomology department and those of the college as a whole. The aim of the introductory course, as conceived by the author, is to provide the student with the opportunity of becoming aware of the existing problems in the field of economic entomology and to learn the essential facts concerning their nature and solution. Two ultimate objectives, which carry both cultural and vocational implications, are suggested for primary consideration in the accomplishment of this aim: (1) to establish and explain the scope of economic entomology and (2) to make pertinent contributions to the preparation needed by the student in the field of economic entomology as a part of the requisites for such vocations as county extension agent, teacher of vocational agriculture, manager of farm cooperative, commercial pest control operator and any others consistent with the objectives established. These may be fur-

ther broken down into more specific objectives according to the apparent needs of the particular student group. Two of these are suggested: (1) provide the student with opportunities for learning to recognize the economic status of insects encountered in agricultural pursuits through a comprehension of the significance of such subject matter fields as: (a) the interrelations of structure and function, (b) the balance of nature, (c) the everchanging practices of agricultural production and distribution, (d) the more practical methods of insect control and husbandry[1]; (2) to provide learning activities which will assist the student in acquiring the information and skills necessary for dealing with problems of agricultural entomology relating to: (a) insects which affect the health, production and distribution of agricultural crops and farm animals, (b) farm practices, appliances and insecticides which are useful in the control of injurious insects, (c) the husbandry of insect products and (d) the rearing and preparing of insects for educational and decorative purposes. Others may be substituted or added at the discretion of the instructor. The following example will suffice to illustrate the manner of evaluating a few commonly recognized subject matter topics of entomological science in relation to the objectives and aim considered essential: The presenting to the student through lectures, textbook readings, laboratory and field exercises of such items of information as the use of fly-free dates in hessian fly control, the timing of alfalfa cutting for leafhopper control, and the application of the principle of the ever normal granary to grain insect control assists directly in the accomplishment of the specific objective "providing the student with the opportunity to recognize the status of insects with respect to the changing practices of agricultural production and distribution, "and thus contributes to preparation for a vocation related to agriculture and eventually to the ultimate aim, *i.e.*, efficient participation in activities characteristic of American rural life. This method of establishing the functional relation of subject matter topics and fields to objectives and aims is of particular value in determining the relative emphasis and time to be allotted to the former; a further consideration of whether these same units are to be established for their knowledge values, are to be developed as general patterns of conduct, or whether they will be needed for application, will determine their relative emphasis in classroom, laboratory and field.

The determination of electives to complement the introductory course will depend somewhat upon the major agricultural interests and the prevalent insect pests of the region in which each agricultural college is located. There appears to be a growing need, particularly in our so-called "machine age," for more adequate offerings in the field of mechanical and chemical control designed to meet the needs of the agricultural student rather than those of the professional major in entomology. The proposed return to our agricultural colleges of qualified ex-service men and women for government-sponsored programs of rehabilitation may necessitate some revision of existing courses in apiculture, household entomology, and those dealing with the relation of insects to wild life, forest, and soil conservation in order to meet the vocational objectives of such programs.

In concluding it should be emphasized that any reorganization of courses and curricula in economic entomology now or during the contemplated period of post-war reconstruction should be made with the view of obtaining closer harmony between objectives and current social and vocational trends. It is no longer enough merely to teach subject matter that is logically ordered. The question "What can entomologists do to increase the appreciation and recognition of the importance of entomology?" was discussed at one of our regional meetings last summer This question may be partially answered through the more effective teaching of introductory courses because it is a properly informed college youth who will acquaint the generations of the future of the importance of entomology in the American way of life.

J. R. EYER

[1] Referring particularly to the propagation and culture of parasites and predators, and the principles and practices involved in bee keeping, silk culture, etc.

OBITUARY

Charles Stewart Beckwith, 1891-1944

Mr. Charles S. Beckwith, Chief, Blueberry and Cranberry Investigations of the New Jersey Agricultural Experiment Station, died of a heart attack, suddenly, the evening of May 18th on a cranberry bog near Pemberton, N. J. Mr. Beckwith had gone to the bog of a cooperating grower with Messrs. J. B. Demaree and Frederick B. Chandler of the U. S. Department of Agriculture to take temperature readings in connection with a frost warning service which he had maintained for many years for the benefit of blueberry and cranberry growers.

Mr. Beckwith was born at Olean, N. Y., May 16, 1891, and was a few days past his 53rd birthday at the time of his death. He was graduated with the degree of Bachelor of Science from Rutgers University in 1914 where he majored in Horticulture. He received the Master of Science degree in Entomology at Rutgers in 1927. Immediately after graduation he joined the staff of the Entomology Department of Rutgers where he carried on research in mosquito control for several years under Doctor Thomas J. Headlee. Beginning in 1917 part of Mr. Beckwith's time was devoted to problems connected with cranberry culture. In the early nineteen twenties this work had grown in importance to a point where the full time of Mr. Beckwith and two assistants was required. The writer was fortunate in being associated with Mr. Beckwith in his work on cranberries and blueberries from 1923 to 1927.

The cranberry and blueberry research was made a separate department of the New Jersey Agricultural Experiment Station in 1931 with laboratories at Pemberton, N. J. Mr. Beckwith, who had headed this work from the beginning, was named Chief of the new department. Current research projects include: (1) investigations to find the carrier of the new blueberry stunt disease; (2) sanding practices on old bogs to rejuvenate the growth of plants; (3) testing of new and promising insecticides for the control of several cranberry and blueberry insects; (4) methods of pruning blueberries and (5) development of suitable fertilizer formulae for cranberries and blueberries.

Investigations directed by Mr. Beckwith in the past have provided, among other benefits, methods of controlling the blunt nosed leafhopper, carrier of the false blossom disease which once threatened the entire cranberry acreage. He also supervised research which led to the control of the blueberry fruit worm and the blueberry weevil. In addition he contributed to the improvement of fertilizer formulae for cranberries and blueberries; worked out principles in the use of flood water on cranberry bogs to control insects and to prevent frost. Mr. Beckwith's published papers dealing with various phases of cranberry and blueberry culture number over 100.

Mr. Beckwith was elected secretary-treasurer of the Eastern Branch of the American Association of Economic Entomologists in November 1943. He was a member of the American Association of Economic Entomologists for many years, a member of the American Association for the Advancement of Science, and secretary of the American Cranberry Growers Association. He had also served as secretary of the New Jersey Blueberry Cooperative Association which he helped to organize in 1927.

Mr. Beckwith was active in community life, having served as Mayor of Pemberton for two terms. He was also chairman of the Pemberton Board of Health, and was a member of the Burlington County Mosquito Extermination Commission.

Mr. Beckwith is survived by his wife, Hilda Stults Beckwith, and two brothers, Earl P. Beckwith of Olean, N. Y. and Frank S. Beckwith, of Dagsboro, Delaware.

B. F. Driggers

Charles Emerson Sanborn, 1877-1944

Professor C. E. Sanborn, Professor of Entomology, Emeritus, at the Oklahoma Agricultural and Mechanical College, died on July 11, 1944, at the age of 67 years. Professor Sanborn was, for 25 years, Entomologist for the Oklahoma Agricultural Experiment Station and was well known to the older members of our Association of which he was formerly an active member. An obituary notice is under preparation.

Harrison Garman, 1858-1944

Professor Harrison Garman, State Entomologist and Botanist of Kentucky for a period of 40 years until his retirement from active service in 1929, died after a long period of ill health since 1938, his 86th year. Professor Garman was a former President of our Association and, during his period of activity, an influential leader in the Association and in the whole profession of Entomology. A more extended obituary notice will be published in the October Journal.

PROCEEDINGS OF THE 29TH ANNUAL MEETING

PACIFIC SLOPE BRANCH, AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

University of California, Berkeley, California, June 27 and 28, 1944

The 29th annual meeting of the Pacific Slope Branch was held at Berkeley, California, June 27 and 28. The members and visitors were welcomed by Professor E. O. Essig, Head of the Department of Entomology and Parasitology at the University of California, and President of the AAEE. Professor Essig also led the discussion of the Effect of the War on Agricultural Entomology. Speakers on this subject included G. F. MacLeod of the War Food Administration, M. P. Jones of the USDA Extension Service, and E. R. deOng of the OPA.

Professor W. B. Herms led the discussion on the Effect of the War on Medical and Veterinary Entomology, in which the principal talk was given by Dr. Stanley B. Freeborn, at present with the U. S. Public Health Service.

Chairman A. J. Flebut led the discussion on the Insecticide Situation, and H. M. Armitage of the California Department of Agriculture led the discussion of Pacific Coast Quarantine Problems. This subject was ably presented by C. E. Cooley of the USDA Bur. of Entomology & Plant Quarantine, and by H. A. Hunt of the California Department of Agriculture.

Mr. S. A. Rohwer, Assistant Chief of the USDA Bur. of Entomology and Plant Quarantine, gave an excellent talk on Postwar Research Problems, and Professor Essig discussed some needed changes in teaching entomology.

After the sessions, the insectary at the University of California was visited, where large-scale production of parasites of the oriental fruit moth is being carried on under the direction of Professor Harry S. Smith.

On Tuesday evening the members and visitors were the guests of the Pacific Coast Insecticide Industry at a smoker and buffet supper which was enjoyed and appreciated by all those attending.

Committees were appointed at the opening session, and they reported at the final session. All reports were accepted by unanimous vote.

TREASURER'S REPORT

1943			
June 7	Balance in bank		$ 8.58
July 1	Balance in funds collected at Corvallis, Ore.		13.57
July 1	Withdrawn to cover remaining 1943 expenses	$ 9.78	
July 13	Refund on 1943 expenses		65.81
1944			
Mar. 31	Stamps	1.00	
June 15	Printing & Mailing Notices & Programs	49.10	
	1943–44 Expenditures	$59.88	
June 27	Balance in bank	28.08	
		$87.96	$87.96

Officers elected for 1944–45 were:

Chairman:	H. J. RYAN, *Los Angeles, Calif.*
Vice-Chairman:	H. M. ARMITAGE, *Sacramento, Calif.*
Sec.-Treas.:	ROY E. CAMPBELL, *Alhambra, Calif.*

Following is the report of the resolutions committee:

RESOLVED: THAT WHEREAS the Insect Pest Survery of the Bureau of Entomology and Plant Quarantine has been of extremely great value to all groups of entomologists throughout this country and has been especially important to the economic entomologists and those interested in insect distribution:

BE IT RESOLVED THAT we, the members of the Pacific Slope Branch of the American Association of Economic Entomologists, assembled in convention at the University of California at Berkeley, June 27 and 28, 1944, recommend most strongly the reestablishment of this survey in some form as soon as possible. We heartily commend the work of J. A. Hyslop and the work of the Bureau in this connection and wish to take this means of lending our influence, if necessary, to the reestablishment of this important work.

BE IT FURTHER RESOLVED THAT recognizing the importance of the special Pest Survey being made at the Maritime Ports and other areas of foreign entry by the Bureau of Entomology and Plant Quarantine we strongly urge the continuance of this survey.

RECOGNIZING, as we all do, the interest long maintained by David B. Mackie as a member of this Association and his great contributions to the fields of economic entomology and plant quarantine, we take this means of spreading on the minutes of this meeting this expression of our everlasting friendship and deep regret in his passing.

WHEREAS members of the Pacific Slope Branch of the American Association of Economic Entomologists have enjoyed a very successful meeting, are deeply grateful to various agencies and organizations who have made this possible—

BE IT FURTHER RESOLVED THAT thanks be extended to—

(1) The local Committee on Arrangements for their careful planning

(2) The Program Committee for their efforts in arranging a most interesting and valuable program.

(3) Those speakers who, at considerable inconvenience to themselves under the present transportation difficulties, have given of their time

(4) The University of California Department of Entomology and Parasitology for their courtesies in providing a suitable meeting place and other conveniences

(5) The Pacific Insecticide Institution for a most delightful buffet supper and entertainment.

H. M. ARMITAGE
R. L. WEBSTER
PAUL JONES

There was a total registered attendance of 160 at the meetings, with the following members present:

Annand, P. N., Washington, D. C.
Armitage, H. M., Sacramento, Calif.
Bolte, E. C., Oakland, Calif.
Bedard, W. D., Berkeley, Calif.
Boissonou, C. J., San Francisco, Calif.
Burden, I. R., San Francisco, Calif.
Campbell, R. E., Alhambra, Calif.
Carman, G. N., Riverside, Calif.
Cassil, C. C., Richmond, Calif.
Cooley, C. E., San Francisco, Calif.
Cressman, A. W., Whittier, Calif.
Cody, L. R., San Jose, Calif.
Coe, E. H., Los Angeles, Calif.
Crawford, H. J., Chico, Calif.
Cannon, E. W., San Jose, Calif.
deOng, E. R., San Francisco, Calif.
DeSellem, F. E., Olympia, Wash.
Dorman, S. C., Emeryville, Calif.
Doyle, E. T., San Francisco, Calif.
Durham, Wallace, Los Angeles, Calif.
Dickson, R. C., Riverside, Calif.
Dohanian, S. M., Eugene, Oregon
Ebeling, Walter, Riverside, Calif.
Eckert, J. E., Davis, Calif.
Elmore, J. C., Alhambra, Calif.
Essig, E. O., Berkeley, Calif.
Foster, A. M., San Jose, Calif.
Flebut, A. J., Berkeley, Calif.
Fenton, A., Houston, Texas
Fulton, R. A., Whittier, Calif.
Fosen, E. H., Sacramento, Calif.
Freitag, J. H., Berkeley, Calif.
Freeborn, S. B., Atlanta, Georgia
Gardner, Leo R., Richmond, Calif.
Gunther, F. A., Riverside, Calif.
Gallion, Ted, San Jose, Calif.
Gressitt, J. L., Berkeley, Calif.
Herms, W. B., Berkeley, Calif.
Hoskins, W. M., Berkeley, Calif.
Hamsher, C. A., Sacramento, Calif.
Hunt, H. A., Sacramento, Calif.
Jeppson, L. R., Berkeley, Calif.
Jones, Paul R., San Francisco, Calif.
Jones, M. L., Sacramento, Calif.
Jones, M. P., Washington, D. C.
Johnson, P. C., Berkeley, Calif.
Jones, Laurence, San Bernardino, Calif.
Johnson, Esler, San Francisco, Calif.
Korsmeier, R. B., Riverside, Calif.
Kirkpatrick, A. F., Lindsay, Calif.
Knowlton, G. F., Ogden, Utah
Kinsley, C. H., Merced, Calif.
Keen, F. P., Berkeley, Calif.
Lange, W. H., Salinas, Calif.
Lindgren, D. L., Riverside, Calif.
Linsley, E. G., Berkeley, Calif.
Laing, G. B., Oakland, Calif.
McClay, A. F., Sacramento, Calif.
MacLeod, G. F., Washington, D. C.
McKenzie, H. L., Sacramento, Calif.
Mote, D. C., Corvallis, Ore.
Osborn, H. T., Los Gatos, Calif.
Persing, C. O., Riverside, Calif.
Parker, Wm. B., Placerville, Calif.
Rayner, D. T., San Jose, Calif.
Romney, Van E., Salinas, Calif.
Roney, J. N., Phoenix, Arizona
Rieder, R. E., Corvallis, Oregon
Rohwer, S. A., Washington, D. C.
Ransford, J. A., San Francisco, Calif.
Ryan, H. J., Los Angeles, Calif.
Schuh, Joe, Corvallis, Oregon
Schwab, O. H., Watsonville, Calif.
Smith, Roy F., Berkeley, Calif.
Smith, H. S., Riverside, Calif.
Smith, Ralph H., Los Angeles, Calif.
Stewart, M. A., Berkeley, Calif.
Struble, G. R., Berkeley, Calif.
Strand, T. P., Watsonville, Calif.
Scullen, H. A., Corvallis, Ore.
Steinweden, J. B., Sacramento, Calif.
Smyth, E. G., Glen Ellen, Calif.
Stafford, E. M., Fresno, Calif.
Swain, A. F., El Monte, Calif.
Urbahns, T. D., Yuba City, Calif.
Van Dyke, E. C., San Francisco, Calif.
Webster, R. L., Pullman, Washington
Wampler, E. L., Wilmington, Calif.

ROY E. CAMPBELL, *Secretary*

The Following Program Was Presented

June 27 and 28, 1944

Chairman: A. J. Flebut, California Spray-Chemical Company, Richmond, Calif.
Vice-Chairman: W. M. Hoskins, University of California, Berkeley, Calif.
Secretary-Treasurer: Roy E. Campbell, USDA Bur. of Ent. & Plant Quar., Alhambra, Calif.

Tuesday, June 27, 1944—9:30 a.m.

BUSINESS MEETING

THE EFFECT OF THE WAR ON AGRICULTURAL ENTOMOLOGY—Discussion Leader, Prof. E. O. Essig, President, American Ass'n. Econ. Entomologists

Economic Poisons as Weapons of War—G. F. MacLeod, War Food Administration, Washington, D. C.

Extension Entomology Activities and the Food and Fiber Programs—M. P. Jones, Extension Service, USDA, Washington, D. C.

The Effect of the War on Truck Crop Insect Control in California—W. H. Lange, Univ. of California, Salinas, Calif.

Orchard Sanitation as a Means of Control of the Filbert Worm—S. M. Dohanian, USDA Bur. of Ent. & Plant Quar., Eugene, Ore.

THE INSECTICIDE SITUATION—Discussion Leader, A. M. Boyce, Univ. of California Citrus Exp. Station, Riverside, Calif.

Wholesale Prices of Insecticides during World Wars I and II, E. R. deOng and M. D. Leonard, Office of Price Administration, Washington, D. C.

The Insecticide Situation in the Pacific Northwest—R. L. Webster, Washington State College, Pullman, Wash.

Tests With DDT in Control of Greenhouse Pests —Ralph H. Smith, University of California, Los Angeles, Calif.

Tuesday, June 27, 1944—2 p.m.

THE EFFECT OF THE WAR ON MEDICAL AND VETERINARY ENTOMOLOGY—Discussion Leader, Prof. W. B. Herms, Univ. of Calif., Berkeley, Calif.

Medical Entomology Meets the Impact of War—Prof. W. B. Herms, University of California, Berkeley, Calif.

Insect Borne Diseases and Returning Troops—Sr. Surgeon Stanley B. Freeborn, U. S. Public Health Service, Atlanta, Ga.

Control of the Ox Warble—M. A. Stewart—University of California, Berkeley, Calif.

Experiments With Some Dinitro-phenolic Compounds as Mosquito Larvicides—Harvey I. Magy and W. M. Hoskins, University of California, Berkeley, Calif.

Toxicity and Repellency of Certain Organic Compounds to Larvae of *Lucillia sericata* (Meig.)—Erwin S. Loeffler, Industrial Lab., U. S. Navy Yard, Mare Island, and W. M. Hoskins, Univ. of Calif., Berkeley, Calif.

PACIFIC COAST QUARANTINE PROBLEMS—Discussion Leader, H. M. Armitage, State Dept. of Agriculture, San Francisco, Calif.

Foreign Plant Quarantine Problems at Pacific Coast Ports—C. E. Cooley, USDA Bur. of Entomology & Plant Quarantine, San Francisco, Calif.

Changing Aspects of Plant Quarantine—H. A. Hunt, State Bur. of Entomology & Plant Quarantine, Sacramento, Calif.

Wednesday, June 28, 1944—9:30 a.m.

POSTWAR ENTOMOLOGICAL PROBLEMS—Discussion Leader, S. A. Rohwer, USDA Bur. of Entomology and Plant Quarantine, Washington, D. C.

Needed Changes in Teaching Entomology—E. O. Essig, Univ. of California, Berkeley, Calif.

Research Problems of the Postwar Period—General Discussion

MISCELLANEOUS PAPERS

Pea Weevil Fumigation with Methyl Bromide, Cyanide and Chloropicrin in Warehouses, Bins, Box Cars, and Vaults—R. D. Eichmann, Wash. Agr. Exp. Sta., State College, Pullman, Wash.

The Poisoning of Honeybees with Special Reference to Methods of Prevention—J. E. Eckert, University of California, Davis, Calif.

Effect of Nicotine on Eggs of the Potato Tuber Moth—Nuri Malih, Univ. of California, Berkeley, Calif.

California Red Scale Populations Following Sprays of Derris Resins & Oil—A. W. Cressman and B. M. Broadbent, USDA Bur. of Entomology & Plant Quarantine, Whittier, Calif.

Effects of *Lygus* spp. on Seed Production and Growth of Guayule in California—Van E. Romney, Geo. T. York, and T. P. Cassidy, USDA Bur. of Entomology & Plant Quarantine, Salinas, Calif.

Wednesday, June 28, 1944—2 p.m.

FINAL BUSINESS SESSION

INSPECTION OF ENTOMOLOGY DEPARTMENT & RESEARCH EQUIPMENT—University of California, Berkeley, Calif.

BOOK REVIEW

A CATALOGUE OF THE PARASITES AND PREDATORS OF INSECT PESTS. By W. R. Thompson, Director, Imperial Parasite Service, Belleville, Ontario, Canada.

For many years, field workers in biological control, as well as taxonomists in several of the major orders, have felt the need of a catalogue that would bring together in usable form the published records of host-parasite relationships. It is, therefore, gratifying that this need is now being filled under the auspices of the Imperial Institute of Entomology by the staff of the Imperial Parasite Service under the direction of Dr. W. R. Thompson. Workers throughout the world are indebted to the Imperial Institute and to Dr. Thompson for undertaking the compilation and publication of this enormous mass of information.

The plan of publication provides for four general sections; (1) Parasite host catalogue (the host species arranged alphabetically by orders and the parasites listed under each host), (2) Parasite catalogue (the parasite species arranged alphabetically by orders and the hosts listed under each parasite), (3) Predator host catalogue (same arrangement as 1), and (4) Predator catalogue (same arrangement as 3). Each section is divided into parts, which are issued separately in multigraph form, 8″×10″ and bound in cloth-covered boards. Parts 1 to 4 of Section I have already been issued, these covering the parasites recorded as being reared from Arachnida and Coleoptera, Dermaptera and Diptera, Hemiptera, and Hymenoptera, Isopoda and Isoptera. The completed catalogue will comprise about 20 parts. The edition is limited to 400 copies for general sale, and prospective purchasers are referred for details to the advertisement in this or preceding issues of the JOURNAL.

The host parasite records contained in the catalogue represent in large part those that have been compiled from the files of the Review of Applied Entomology, which dates from 1913. It, therefore, covers the published records of a 30-year period, which total more than 100,000, and no attempt has been made to include data published prior to that time. The omissions in the Review are, to a considerable extent, reflected in the catalogue also.

Each parasite record under the host insect is accompanied by the family name, country in which the observation was made and the Review reference by volume and page. The user of the Catalogue will, therefore, need to refer to the Review in order to obtain the original reference. In a publication of this type, the problem of nomenclature has proven to be exceedingly difficult, and for that reason the names are given as they appear in the original records. A special effort has been made, however, to assemble all records of a single insect under a single name, and a considerable amount of revision has thus been necessary in order to link up citations of the same species that have appeared under different names. Host synonymy not shown in the text is given in a separate list at the end of each part. An index to parasite species is also included.

Field workers have long recognized that a very considerable portion of the published parasite records are erroneous with respect to the host relationships. The compilers of the catalogue are obviously unable to judge the correctness of the records and consequently all have been listed as published, even when known to be erroneous.

This catalogue, when completed, will represent an exceedingly useful addition to entomological literature.

C. P. CLAUSEN